Table 4-13 I-81 Ramp Level of Service Analysis Summary (Continued)

	Northbound Ramps						Southbound Ramps					
	2004 Peak Hour			2035 Peak Hour			2004 Peak Hour			2035 Peak Hour		
	Volume[1]	Density[2]	LOS[3]	Volume	Density	LOS	Volume	Density	LOS	Volume	Density	LOS
Exit 220 Off-Ramp	200	15.4	B	350	39.7	F	500	21.3	C	750	40.3	F
Exit 221 On-Ramp	1050	17.0	B	1650	39.9	E	1100	19.5	B	1200	37.5	E
Exit 221 Off-Ramp	800	15.7	B	1300	39.5	F	1000	18.3	B	1850	43.8	F
Exit 222 On-Ramp	350	18.0	B	650	40.7	E	550	19.5	B	1000	42.1	E
Exit 222 Off-Ramp	400	11.2	B	900	28	C	300	20.3	C	600	48.6	F
Exit 225 On-Ramp	200	14.5	B	350	34.4	D	350	16.8	B	650	42	F
Exit 225 Off-Ramp	350	20.7	C	600	46.3	F	250	17.3	B	350	39.4	F
Exit 227 On-Ramp	150	13.5	B	300	32.5	D	300	14.1	B	600	33.9	D
Exit 227 Off-Ramp	300	16.0	B	550	38.1	F	200	16.2	B	300	36.5	E
Exit 235 On-Ramp	200	14.8	B	450	34.5	D	200	13.4	B	350	31.7	D
Exit 235 Off-Ramp	200	14.7	B	350	35.8	E	300	19.9	B	400	43.9	F
Exit 240 On-Ramp	200	9.4	A	400	29.1	D	250	14.5	B	400	36	F
Exit 240 Off-Ramp	200	10.1	B	400	32.1	D	200	10.8	B	350	30.4	D
Exit 243 On-Ramp	350	11.4	B	600	30.3	D	250	11.9	B	550	29.5	D
Exit 243 Off-Ramp	200	10.5	B	550	32.5	D	250	11.4	B	700	32.6	D
Exit 245 On-Ramp	350	15.2	B	650	36.8	E	500	9.1	A	700	28	C
Exit 245 Off-Ramp	350	7.3	A	700	28.4	D	250	6.3	A	600	28.8	D
Exit 247A On-Ramp	115	16.2	B	160	31.2	D	340	9.6	A	710	29.6	D
Exit 247A Off-Ramp	420	15.8	B	870	40.8	F	30	12.1	B	85	31.2	D
Exit 247B On-Ramp	435	11.5	B	590	25.3	C	260	13.4	B	540	30.6	D
Exit 247B Off-Ramp	230	18.0	B	480	38	E	320	6.7	A	915	29.1	D
Exit 251 On-Ramp	100	9.2	A	200	23.1	C	100	8.8	A	250	29	D
Exit 251Off-Ramp	150	11.7	B	250	27.3	C	100	9.5	A	200	33.3	D
Exit 257 On-Ramp	50	12.1	B	50	24.7	C	200	10.2	B	500	31.3	D
Exit 257 Off-Ramp	350	10.9	B	500	26.4	C	50	6.2	A	50	27	C
Exit 264 On-Ramp	150	7.6	A	350	20.3	C	150	2.2	A	450	20.5	C
Exit 264 Off-Ramp	200	7.1	A	350	21	C	150	5.8	A	350	23.7	C
Exit 269 On-Ramp	50	9.1	A	150	25.3	C	100	12.5	B	150	28.7	D
Exit 269 Off-Ramp	100	11.9	B	200	26.2	C	50	4.3	A	100	22.2	C
Exit 273 On-Ramp	250	8.8	A	450	21.9	C	100	4.0	A	250	20.4	C
Exit 273 Off-Ramp	150	8.5	A	300	26.7	C	200	4.6	A	400	23.1	C
Exit 277 On-Ramp	NO NORTHBOUND RAMP						50	6.3	A	50	23	C
Exit 277 Off-Ramp	50	9.4	A	50	24.1	C	NO SOUTHBOUND RAMP					
Exit 279 On-Ramp	100	11.1	A	200	27.9	C	50	3.7	A	150	21.8	C
Exit 279 Off-ramp	100	5.1	A	150	19.9	B	100	7.7	A	200	27.9	C
Exit 283 On-Ramp	250	7.7	A	550	23.2	C	250	5.6	A	500	23.6	C
Exit 283 Off-Ramp	250	9.8	A	500	28.7	D	350	9.1	A	550	28.9	D

Note: Shaded sections are locations where substandard LOS is indicated.
1 Ramp volume expressed in vehicles per hour (vph)
2 Density expressed in passenger cars per mile per hour
3 LOS - Level of Service

Table 4-13 I-81 Ramp Level of Service Analysis Summary (Continued)

	Northbound Ramps						Southbound Ramps					
	2004 Peak Hour			2035 Peak Hour			2004 Peak Hour			2035 Peak Hour		
	Volume[1]	Density[2]	LOS[3]	Volume	Density	LOS	Volume	Density	LOS	Volume	Density	LOS
Exit 291 On-Ramp	200	10.7	B	500	29.4	D	150	7.6	A	400	25.9	C
Exit 291 Off-Ramp	200	8.1	A	350	25.7	C	300	10.9	B	600	33	D
Exit 296 On-Ramp	100	8.9	A	250	25	C	50	14.3	B	150	34.1	D
Exit 296 Off-Ramp	100	14.9	B	150	35.7	E	200	14.8	B	250	32.9	D
Exit 298 On-Ramp	300	13.6	B	650	36.7	E	100	9.3	A	200	25.7	C
Exit 298 Off-Ramp	50	4.9	A	150	23	C	400	14.7	B	600	39.4	F
Exit 300 On-Ramp	550	16.3	B	900	36.7	E	800	21.2	C	1300	45.7	E
Exit 300 Off-Ramp	650	11.4	B	1150	37.9	F	450	1.8	A	950	20.6	C
Exit 302 On-Ramp	200	12.4	B	500	31.2	D	100	13.4	B	250	30.3	D
Exit 302 Off-Ramp	100	15.2	B	200	36.7	E	250	15.7	B	500	35.5	E
Exit 307 On-Ramp	400	18.0	B	950	41	E	250	16.6	B	500	34.4	D
Exit 307 Off-Ramp	250	12.8	B	500	34	D	450	18.7	B	850	41.9	F
Exit 310 On-Ramp	400	17.0	B	750	36.7	E	700	19.8	B	1100	40.6	E
Exit 310 Off-Ramp	500	17.6	B	1200	43.8	F	450	15.2	B	750	35.5	E
Exit 313A On-Ramp	NO NORTHBOUND RAMPS						435	6.1	A	730	24.1	C
Exit 313A Off-Ramp	NO NORTHBOUND RAMPS						485	17.4	B	1105	40.9	F
Exit 313B On-Ramp	1250	22.6	C	2050	44.3	E	165	18.1	B	270	39.4	E
Exit 313B Off-Ramp	550	16.8	B	1000	39	E	415	18.6	B	945	46.5	F
Exit 315 On-Ramp	800	24.5	C	1300	48.5	E	800	19.6	B	1450	44.6	E
Exit 315 Off-Ramp	750	22.1	C	1250	46.6	F	500	15.4	B	1200	43.5	F
Exit 317 On-Ramp	450	19.2	B	750	38.2	E	700	15.9	B	1650	40.6	E
Exit 317 Off-Ramp	850	24.5	C	1650	51.6	F	300	13.3	B	800	38.9	E
Exit 321 On-Ramp	50	18.4	B	100	35.2	E	100	14.1	B	250	37.3	E
Exit 321 Off-Ramp	100	19.3	B	200	40.4	F	50	10.5	B	100	33.3	D
Exit 323 On-Ramp	150	16.6	B	400	32.8	D	200	11.8	B	600	32.4	D
Exit 323 Off-Ramp	250	17.1	B	600	35.7	E	150	10.6	B	400	31.8	D

Note: Shaded sections are locations where substandard LOS is indicated.

1 Ramp volume expressed in vehicles per hour (vph)

2 Density expressed in passenger cars per mile per hour

3 LOS - Level of Service

Weaving Operations

As mentioned previously, there are 10 weaving sections along I-81. The analyses, the results of which are summarized in Table 4-14 and shown on Figure 4-9, account for interaction between the weaving vehicles and how they affect general traffic operations along the mainline and the ramps. Under peak conditions, four (two northbound and two southbound) of the weaving sections are projected to operate worse than the level of service standard.

Table 4-14 2035 I-81 Weaving Operations Summary

Segment		2004 Peak Hour Density[1]	2004 Peak Hour LOS[2]	2035 Peak Hour Density	2035 Peak Hour LOS
Exit 14	Northbound	18.1	B	35.2	E
Exit 89	Northbound	10.2	B	23.6	C
Exit 94	Northbound	10.3	B	24.8	C
Exit 118	Northbound	13.9	B	35.8	E
Exit 247	Northbound	10.6	B	23.6	C
Exit 89	Southbound	8.9	A	21.0	C
Exit 118	Southbound	1.2	A	2.0	A
Exit 150	Southbound	13.2	B	39.4	E
Exit 247	Southbound	8.5	A	25.7	C
Exit 313	Southbound	14.0	B	39.1	E

Note: Shaded sections are locations where substandard LOS is indicated.
1 Density -- Expressed in passenger cars per vehicle per lane
2 LOS -- Level of Service

4.2.2 Intersection Level of Service

Intersection capacity analyses were conducted for all of the signalized and unsignalized intersections analyzed in Chapter 3. The analyses were based on the 2035 No-Build intersection volumes, existing intersection geometry, and existing traffic control. For cases where intersection improvements are planned and funded (as part of the Virginia Transportation Six-year Improvement Plan) or underway, the analysis has been modified as appropriate.

Unsignalized Intersections

Signalization improvements were not considered for this analysis except where plans are identified and funded as part of the Six-Year Transportation Plan (one location). A summary of the unsignalized intersection analyses results under existing and future 2035 No-Build conditions is presented in Table 4-15. In addition to the existing deficiencies discussed in Chapter 3, which are expected to continue under No-Build conditions, 46 additional intersections are projected to become deficient.

While deficient intersections are widespread under 2035 No-Build conditions, the area of Harrisonburg north to the West Virginia State Line sees the greatest impact where (with the exception of Exits 269, 299, 321, and 323) all intersections are projected to operate at a deficient level of service. The areas of Bristol, Marion, and Wytheville also see a substantial degradation in level of service.

Signalized Intersections

Signalized intersection capacity analyses were also performed for the 2035 No-Build conditions. In addition to the existing deficiencies discussed in Chapter 3, which are expected to continue under No-Build conditions, 12 additional intersections are projected to become deficient. The results are summarized in Table 4-15. Signalized intersections in Winchester continue to be deficient, while isolated intersections in Bristol, Wytheville, and Harrisonburg are projected to be deficient as well.

Table 4-15 2035 Intersection Operations Summary

Intersection[1]	Critical Movement[2]	Existing Conditions Delay[3]	Existing Conditions LOS[4]	2035 Conditions Delay	2035 Conditions LOS
Exit 1 NB Ramps @ U.S. Routes 58/421	NB Off-Ramp LT	20.0	C	63.0	F
Exit 1 SB Ramps @ U.S. Routes 58/421	Rte 611 WB L	8.2	A	9.0	A
Exit 5 NB Off-Ramp @ U.S. Rtes 11/19	**Intersection**	**11.6**	**B**	**120+**	**F**
Exit 5 NB On-Ramp @ U.S. Rtes 11/19	Rtes 11/19 EB L	11.6	B	42.9	E
Exit 5 SB Ramps @ U.S. Routes 11/19	**Intersection**	**10.8**	**B**	**58.9**	**E**
Exit 7 NB Ramps @ Old Airport Rd.	**Intersection**	**57.0**	**E**	**120+**	**F**
Exit 7 SB Ramps @ Old Airport Rd.	**Intersection**	**90.5**	**F**	**120+**	**F**
Exit 10 NB Ramps @ U.S. Route 11	NB Off-Ramp LTR	11.9	B	47.7	E
Exit 10 SB Ramps @ U.S. Route 11	SB Off-Ramp LTR	10.1	B	15.2	C
Exit 13 NB Ramps @ Route 611	NB Off-Ramp LTR	12.7	B	73.3	F
Exit 13 SB Ramps @ Route 611	SB Off-Ramp LTR	11.1	B	23.9	C
Exit 14 NB Ramps @ Route 647	NB Off-Ramp L	13.0	B	31.2	D
Exit 14 SB Ramps @ Route 140	SB Off-Ramp LTR	27.7	D	120+	F
Exit 14 NB Ramps @ U.S. Route 11	Rte 647 WB LT	9.1	A	12.8	B
Exit 17 NB Ramps @ Routes 75/58	**Intersection**	**15.4**	**B**	**120+**	**F**
Exit 17 SB Ramps @ Route 75/U.S. Route 58	**Intersection**	**38.1**	**D**	**120+**	**F**
Exit 19 NB Ramps @ U.S. Route 11	NB Off-Ramp L	36.8	E	120+	F
Exit 19 SB Ramps @ U.S. Routes 11/58	SB Off-Ramp LR	14.3	B	120+	F
Exit 22 SB Ramps @ Route 704	SB Off-Ramp L	10.4	B	14.2	B
Exit 22 NB Ramps @ Route 704	NB Off-Ramp LT	10.8	B	16.8	C
Exit 24 NB Ramps @ Route 80	NB Off-Ramp LTR	10.3	B	13.1	B
Exit 24 SB Ramps @ Route 80	SB Off-Ramp LTR	10.8	B	13.0	B
Exit 26 NB Ramps @ Route 737	NB Off-Ramp LTR	10.7	B	14.7	B
Exit 26 SB Ramps @ Route 737	SB Off-Ramp LTR	9.9	A	12.6	B
Exit 29 NB Ramps @ Route 91	NB Off-Ramp L	13.2	B	120+	F
Exit 29 SB Ramps @ Route 91	SB Off-Ramp LTR	13.6	B	120+	F
Exit 32 NB Ramps @ U.S. Route 11/Route 751	NB Off-Ramp LTR	10.0	A	12.6	B
Exit 32 SB On-Ramp @ Rtes 11/751	Rte 751SB LTR	8.5	A	13.3	B
Exit 32 SB Off-Ramp @ U.S. Route 11/Route 751	SB Off-Ramp LR	10.0	B	13.1	B
Exit 35 NB Ramps @ Routes 763/107	NB Off-Ramp LTR	99.8	F	120+	F
Exit 35 SB Ramps @ Routes 763/107	SB Off-Ramp LTR	39.0	E	120+	F
Exit 39 NB Ramps @ Routes 11/645	NB Off-Ramp LT	14.1	B	64.7	F
Exit 39 SB Ramps @ Routes 11/645	SB Off-Ramp LT	13.1	B	61.3	F
Exit 44 NB Ramps @ U.S. Route 11	NB Off-Ramp L	16.4	C	48.8	E
Exit 44 SB Ramps @ U.S. Route 11	Rte 11 SB L	8.2	A	9.8	A
Exit 44 SB Ramps @ U.S. Route 11	SB Off-Ramp LR	8.8	A	9.0	A
Exit 44 SB Ramps @ U.S. Route 11	Rte 730 EB LTR	7.3	A	7.5	A

Note: Shaded sections are locations where substandard LOS is indicated.
1 Signalized Intersections are displayed in bold print, and Delay and LOS data listed applies to the overall intersection.
2 Delay and LOS data listed for unsignalized intersections are for either the critical movement on the cross street or the minor (off-ramp) approach.
3 Delay - Average delay, expressed in seconds per vehicle. Delays in excess of two minutes are listed as '120+' seconds.
4 LOS – Level of Service.

Table 4-15 2035 Intersection Operations Summary (Continued)

Intersection[1]	Critical Movement[2]	Existing Conditions Delay[3]	Existing Conditions LOS[4]	2035 Conditions Delay	2035 Conditions LOS
Exit 45 NB Ramps @ Route 16	NB Off-Ramp LT	17.0	C	120+	F
Exit 45 SB Ramps @ Route 16	SB Off-Ramp LT	15.5	C	77.1	F
Exit 47 NB Ramps @ Route F-010	Rte F-010 EB L	8.7	A	11.8	B
Exit 47 NB Ramps @ Route F-010	NB Off-Ramp L	8.4	A	12.4	B
U.S. Route 11 @ Route F-010	Rte F-010 WB L	26.9	D	120+	F
Exit 47 SB Ramps @ U.S. Route 11	SB Off-Ramp LR	15.7	C	76.9	F
Exit 47 SB Ramps @ Route F-010	Rte F-010 WB L	8.1	A	8.9	A
Exit 50 NB Ramps @ Route 622	NB Off-Ramp LTR	10.1	B	26.2	D
Exit 50 SB Ramps @ Route 622	SB Off-Ramp LTR	9.7	A	17.2	C
Exit 54 NB Ramps @ Route 683	NB Off-Ramp LTR	9.1	A	10.6	B
Exit 54 SB Ramps @ Route 683	SB Off-Ramp LTR	9.8	A	11.0	B
Exit 60 NB Ramps @ Routes 90/680	NB Off-Ramp LTR	10.4	B	16.1	C
Exit 60 SB Ramps @ Routes 90/680	SB Off-Ramp LTR	12.1	B	56.0	F
Exit 67 NB Ramps @ U.S. Route 11	NB Off-Ramp LR	12.1	B	16.5	C
Exit 67 SB Ramps @ U.S. Route 11	NB Rte 11 LT	8.0	A	8.5	A
Exit 70 NB Ramps @ U.S. Routes 52/21	NB Off-Ramp LTR	15.1	C	120+	F
Exit 70 SB Ramps @ U.S. Routes 52/21	SB Holston LTR	38.4	E	120+	F
Exit 70 SB Ramps @ U.S. Routes 52/21	SB Off-Ramp LR	25.1	D	120+	F
Exit 77 NB Ramps @ U.S. Routes 11/52/Route 336	NB Off-Ramp LTR	15.5	C	120+	F
Exit 77 SB Ramps @ U.S. Routes 11/52/Route 336	SB Off-Ramp LTR	35.2	E	120+	F
Exit 80 NB Ramps @ U.S. Routes 52/121	**Intersection**	7.9	A	71.7	E
Exit 80 SB Ramps @ U.S. Routes 52/121	**Intersection**	30.3	C	115.8	F
Exit 84 NB Ramps @ Route 619	NB Off-Ramp LTR	12.4	B	120+	F
Exit 84 SB Ramps @ Route 619	SB Off-Ramp LTR	10.9	B	26.3	D
Exit 86 NB Ramps @ Route 618	NB Off-Ramp LTR	9.9	A	12.0	B
Exit 86 SB Ramps @ Route 618	SB Off-Ramp LTR	9.5	A	11.1	B
Exit 92 NB Ramps @ Old Route 100	NB Off-Ramp LTR	9.0	A	9.4	A
Exit 92 SB Ramps @ Old Route 100	SB Off-Ramp LTR	9.7	A	10.1	B
Exit 94 SB Off Ramp @ Route 99	SB Off-Ramp LT	14.8	B	48.5	E
Exit 94 SB On Ramp @ Route 99	WB Route 99 L	7.7	A	1.7	A
Exit 98 NB Off Ramp @ Route 100	NB Off-Ramp LR	35.9	E	120+	F
Exit 98 NB On Ramp @ Route 100	EB Route 100 L	11.4	B	75.6	F
Exit 98 SB Ramps @ Route 100	SB Off-Ramp L	66.2	F	120+	F
Exit 101 NB Ramps @ Route 660	NB Off-Ramp LT	11.9	B	32.2	D
Exit 101 SB Ramps @ Route 660	SB Off-Ramp LT	12.9	B	23.7	C
Exit 105 SB Ramps @ Rts 232 & 605	SB Off-Ramp R	9.7	A	12.3	B

Note: Shaded sections are locations where substandard LOS is indicated.

1 Signalized Intersections are displayed in bold print, and Delay and LOS data listed applies to the overall intersection.

2 Delay and LOS data listed for unsignalized intersections are for either the critical movement on the cross street or the minor (off-ramp) approach.

3 Delay - Average delay, expressed in seconds per vehicle. Delays in excess of two minutes are listed as ‘120+’ seconds.

4 LOS – Level of Service.

Table 4-15 2035 Intersection Operations Summary (Continued)

		Existing Conditions		2035 Conditions	
Intersection[1]	Critical Movement[2]	Delay[3]	LOS[4]	Delay	LOS
Exit 109 NB Ramps @ Route 177	NB Off Ramp LT	120+	F	120+	F
Exit 109 SB Ramps @ Route 177	SB Off Ramp LT	59.5	F	120+	F
Exit 114 NB Ramps @ Route 8	NB Off Ramp LT	120+	F	120+	F
Exit 114 SB Ramps @ Route 8	SB Off Ramp LT	119.4	F	120+	F
U.S. Rt. 460 WB Off Ramp @ U.S. Rt. 460 Bus	**Intersection**	**10.6**	**B**	**17.9**	**B**
U.S. Rt. 460 EB Off Ramp @ U.S. Rt. 460 Bus	**Intersection**	**12.0**	**B**	**32.3**	**C**
Exit 118C NB Ramps @ U.S. Route 460	NB Off Ramp L	29.1	D	41.0	E
Exit 118C SB Ramps @ U.S. Route 460	SB Off Ramp L	120+	F	120+	F
Exit 128 NB Ramps @ Route 603	NB Off Ramp LT	13.1	B	18.9	C
Exit 128 SB Ramps @ Route 603	SB Off Ramp LT	11.6	B	13.9	B
Exit 132 NB Ramps @ Route 647	NB Off Ramp LT	12.2	B	13.7	B
Exit 132 SB Ramps @ Route 647	SB Off Ramp LT	14.9	B	21.6	C
Exit 137 NB Ramps @ Route 112	NB Off Ramp LT	23.4	C	74.1	F
Exit 137 SB Ramps @ Route 112	SB Off Ramp R	15.1	C	108.7	F
Exit 140 NB Ramps @ Route 311	NB Off Ramp LT	61.8	F	120+	F
Exit 140 SB Ramps @ Route 311	SB Off Ramp L	18.5	C	34.6	D
Exit 141 NB Ramps @ Route 419	NB Off Ramp LR	50.6	F	N/A	N/A
Exit 141 NB Ramps @ Route 419	**Intersection**	**N/A**	**N/A**	**13.4**	**B**
Exit 141 SB Off Ramp @ Route 419	SB Off Ramp L	120+	F	N/A	N/A
Exit 141 SB Off Ramp @ Route 419	**Intersection**	**N/A**	**N/A**	**15.3**	**B**
Exit 141 SB On Ramp @ Route 419	WB Route 419 L	10.2	B	16.8	C
Exit 146 NB Ramps @ Rts 115/185	NB Off Ramp R	20.5	C	120+	F
Exit 146 SB Ramps @ Rts 115/185	SB Off Ramp LT	120+	F	120+	F
Exit 150 NB Off Ramp @ U.S. Route 11	NB Off Ramp L	32.6	D	93.0	F
Exit 150 NB On Ramp @ U.S. Route 220	EB Route 220 L	25.1	D	120+	F
Exit 150 SB Ramps @ U.S. Route 220	SB Off Ramp R	15.1	C	18.8	C
U.S. Route 11 & U.S. Route 220	**Intersection**	**47.3**	**D**	**94.6**	**F**
Exit 156 NB Ramps @ Route 640	NB Off Ramp LTR	10.6	B	11.4	B
Exit 156 SB Ramps @ Route 640	SB Off Ramp LTR	11.0	B	12.3	B
Exit 162 NB Ramps @ U.S. Route 11	NB Off Ramp LT	13.6	B	17.1	C
Exit 162 SB Ramps @ U.S. Route 11	SB Off Ramp LR	11.5	B	15.7	C
Exit 167 SB Ramp @ U.S. Route 11	SB Off Ramp LR	10.4	B	13.9	B
Exit 168 NB Ramps @ Route 614	NB Off Ramp LTR	9.2	A	9.6	A
Exit 175 NB Ramps @ U.S. Route 11	NB Off Ramp LTR	8.8	A	9.0	A
Exit 175 SB Ramps @ U.S. Route 11	SB Off Ramp LT	9.5	A	10.6	B

Note: Shaded sections are locations where substandard LOS is indicated.
1 Signalized Intersections are displayed in bold print, and Delay and LOS data listed applies to the overall intersection.
2 Delay and LOS data listed for unsignalized intersections are for either the critical movement on the cross street or the minor (off-ramp) approach.
3 Delay - Average delay, expressed in seconds per vehicle. Delays in excess of two minutes are listed as '120+' seconds.
4 LOS – Level of Service.

Table 4-15 2035 Intersection Operations Summary (Continued)

Intersection[1]	Critical Movement[2]	Existing Conditions Delay[3]	Existing Conditions LOS[4]	2035 Conditions Delay	2035 Conditions LOS
Exit 180 NB Ramps @ U.S. Route 11	NB Off Ramp LR	10.6	B	15.4	C
Exit 180 SB Ramps @ U.S. Route 11	Service Road LR	9.7	A	12.1	B
Exit 188 NB On Ramp @ U.S. Route 60	EB Route 60 L	8.6	A	9.1	A
Exit 188 SB Off Ramp @ U.S. Route 60	SB Off Ramp R	10.6	B	11.4	B
Exit 195 NB Ramps @ U.S. Route 11	NB Off Ramp LTR	13.9	B	51.1	F
Exit 195 SB Ramps @ U.S. Route 11	SB Off Ramp LT	13.1	B	19.6	C
Exit 200 NB Ramps @ Route 710	NB Off Ramp LTR	11.3	B	15.0	B
Exit 200 SB Ramps @ Route 710	SB Off Ramp LTR	11.3	B	20.7	C
Exit 205 NB Ramps @ Route 606	NB Off Ramp LTR	13.7	B	120+	F
Exit 205 SB Ramps @ Route 606	SB Off Ramp LTR	16.2	C	120+	F
Exit 213 NB Ramps @ U.S. Route 11	NB Off Ramp LT	14.3	C	18.3	C
Exit 213 SB Ramps @ U.S. Route 11	WB L U.S. Route 11	7.9	A	8.4	A
Exit 217 NB Ramps @ Route 654	NB Off Ramp LTR	15.4	C	41.0	E
Exit 217 SB Ramps @ Route 654	SB Off Ramp LTR	16.5	C	62.8	F
Exit 222 NB Off Ramp @ U.S. Route 250	NB Off Ramp L	59.1	F	120+	F
Exit 222 NB On Ramp @ U.S. Route 250	EB Route 250 L	11.1	B	14.0	B
Exit 222 SB Ramps @ U.S. Route 250	**Intersection**	**6.3**	**A**	**11.8**	**B**
Exit 225 NB Ramps @ Route 275	NB Off Ramp LT	120+	F	120+	F
Exit 225 SB Ramps @ Route 275	SB Off Ramp LT	23.5	C	87.6	F
Exit 227 NB Ramps @ Route 612	NB Off Ramp LT	120+	F	120+	F
Exit 227 SB Off Ramp @ Route 612	SB Off Ramp L	14.4	B	19.6	C
Exit 227 SB On Ramp @ Route 612	WB Route 612 L	8.9	A	9.9	A
Exit 235 NB Ramps @ Route 256	NB Off Ramp LTR	21.2	C	120+	F
Exit 235 SB Ramps @ Route 256	SB Off Ramp LTR	98.3	F	120+	F
Exit 240 NB Ramps @ Rts 257 & 682	NB Off Ramp LTR	29.4	D	120+	F
Exit 240 SB Ramps @ Rts 257 & 682	SB Off Ramp LTR	11.8	B	23.4	C
Exit 245 NB Ramps @ Rte. 659	**Intersection**	**21.7**	**C**	**120+**	**F**
Exit 245 SB Ramps @ Rte. 659	**Intersection**	**18.4**	**B**	**120+**	**F**
Exit 257 NB Ramps @ U.S. Route 11	NB Off-Ramp LTR	28.1	D	120+	F
Exit 257 SB On-Ramp @ U.S. Route 11	**Intersection**	**10.9**	**B**	**91.1**	**F**
Exit 257 SB Off-Ramp @ Route 259	WB Off-Ramp LR	12.3	B	18.8	C
Exit 264 NB Ramps @ U.S. Route 211	NB Off-Ramp L	23.3	C	120+	F
Exit 264 SB Ramps @ Route 211	SB Off-Ramp LTR	23.2	C	120+	F
Exit 269 NB Ramps @ Route 730	NB Off-Ramp LTR	10.2	B	15.4	C
Exit 269 SB Ramps @ Route 730	SB Off-Ramp LTR	10.4	B	13.4	B

Note: Shaded sections are locations where substandard LOS is indicated.
1 Signalized Intersections are displayed in bold print, and Delay and LOS data listed applies to the overall intersection.
2 Delay and LOS data listed for unsignalized intersections are for either the critical movement on the cross street or the minor (off-ramp) approach.
3 Delay - Average delay, expressed in seconds per vehicle. Delays in excess of two minutes are listed as '120+' seconds.
4 LOS – Level of Service.

Table 4-15 2035 Intersection Operations Summary (Continued)

Intersection[1]	Critical Movement[2]	Existing Conditions Delay[3]	Existing Conditions LOS[4]	2035 Conditions Delay	2035 Conditions LOS
Exit 273 NB Ramps @ Route 292	NB Off-Ramp LT	13.0	B	27.2	D
Exit 273 SB Ramps @ Route 292	SB Off-Ramp L	16.2	C	120+	F
Exit 277 NB Ramps @ Route 614	NB Off-Ramp LR	9.5	A	9.5	A
Exit 277 SB Ramps @ Route 614	Rte. 614 WB LT	7.5	A	7.5	A
Exit 279 NB Ramps @ Route 185	NB Off-Ramp LR	12.1	B	30.2	D
Exit 279 SB Ramps @ Route 185	SB Off-Ramp LTR	11.9	B	36.4	E
Exit 283 NB Ramps @ Route 42	**Intersection**	**15.0**	**B**	**120+**	**F**
Exit 283 SB Ramps @ Route 42	**Intersection**	**13.3**	**B**	**120+**	**F**
Exit 291 NB Ramps @ Route 651	NB Off-Ramp L	30.0	D	120+	F
Exit 291 SB Ramps @ Route 651	SB Off-Ramp L	19.4	C	120+	F
Exit 296 NB Ramps @ Route 55	NB Off-Ramp L	14.0	B	41.0	E
Exit 296 SB Ramps @ Route 55	SB Off-Ramp LT	13.6	B	39.7	E
Exit 298 NB Ramps @ U.S. Route 11	NB Off-Ramp LT	21.3	C	120+	F
Exit 298 SB Ramps @ U.S. Route 11	SB Off-Ramp LTR	50.3	F	120+	F
Exit 302 NB Ramps @ Route 627	NB Off-Ramp LTR	15.0	B	120+	F
Exit 302 SB Ramps @ Route 627	SB Off-Ramp L	12.3	B	32.6	D
Exit 307 NB Ramps @ Route 277	**Intersection**	**42.5**	**D**	**120+**	**F**
Exit 307 SB Ramps @ Route 277	**Intersection**	**21.8**	**C**	**120+**	**F**
Exit 310 NB Ramps @ Route 37	**Intersection**	**78.3**	**E**	**120+**	**F**
Exit 310 SB Ramps @ Route 37	**Intersection**	**9.7**	**A**	**98.1**	**F**
Exit 313 NB Ramps @ U.S. Rts 17/50/522	**Intersection**	**56.9**	**E**	**120+**	**F**
Exit 315 NB Ramps @ U.S. Route 7	**Intersection**	**120+**	**F**	**120+**	**F**
Exit 315 SB Ramps @ Route 7	**Intersection**	**58.3**	**D**	**120+**	**F**
Exit 317 NB Off-Ramp @ U.S. Route 11	**Intersection**	**43.6**	**D**	**120+**	**F**
Exit 317 NB On-Ramp @ U.S. Route 11	Route 661 NB LTR	120+	F	120+	F
Exit 317 SB Ramps @ U.S. Route 11	U.S. Route 11 WB L	11.9	B	120+	F
Exit 321 NB Ramps @ Route 672	NB Off-Ramp LTR	9.9	A	13.9	B
Exit 321 SB Ramps @ Route 672	SB Off-Ramp L	11.2	B	20.0	C
Exit 323 NB Ramps @ Route 669	**Intersection**	**11.3**	**B**	**22.9**	**C**
Exit 323 SB Ramps @ Route 669	**Intersection**	**13.4**	**B**	**52.5**	**D**

Note: Shaded sections are locations where substandard LOS is indicated.
1 Signalized Intersections are displayed in bold print, and Delay and LOS data listed applies to the overall intersection.
2 Delay and LOS data listed for unsignalized intersections are for either the critical movement on the cross street or the minor (off-ramp) approach.
3 Delay - Average delay, expressed in seconds per vehicle. Delays in excess of two minutes are listed as '120+' seconds.
4 LOS – Level of Service.

4.2.3 2035 No-Build Conditions on U.S. Route 11

By 2035, without any improvements to I-81, U.S. Route 11 traffic will continue to grow as well. Areas expected to see the largest increases include the Harrisonburg and Winchester urbanized areas. These projections reflect congestion anticipated on both I-81 and U.S. Route 11 if no improvements are completed on I-81. As shown in Table 4-16, a majority of the traffic volumes on Route 11 are expected to double by 2035.

Table 4-16 Existing and 2035 Future Traffic Volumes on U.S. Route 11

	Daily Two-Way Traffic Volumes on U.S. Route 11	
Location[1]	Existing	2035 No-Build
Tennessee State Line	16,970	27,065
Washington/Smyth	2,820	7,210
Smyth/Wythe	2,600	3,075
South of Exit #72	10,600	4,985
Between Exit #72 and #81	*53,040*	*91,460*
North of Exit #81	*38,200*	*87,070*
Pulaski/Montgomery	26,520	18,075
Montgomery/Roanoke	10,000	23,550
South of Exit #137	19,100	26,110
North of Exit #146	15,140	25,810
Roanoke/Botetourt	15,140	25,810
South of Exit #191	16,980	19,000
Rockbridge/Augusta	3,760	14,985
North of Exit #221	3,300	10,150
Augusta/Rockingham	6,260	15,605
South of Exit #247	13,800	45,555
North of Exit #251	4,980	18,560
Rockingham/Shenandoah	4,880	18,150
Shenandoah/Frederick	4,040	15,445
South of Exit #310	9,760	18,405
South of Exit #317	11,670	72,375
West Virginia State Line	4,460	13,650

1. Locations in italics indicate roadway sections where U.S. Route 11 is signed concurrently with I-81.

5

2035 "Build" Conditions and Concept Analysis

This chapter presents the transportation results of the Tier 1 DEIS improvement concepts examined to address corridor deficiencies for the entire 325-miles of I-81. The methods and assumptions used for the development of these concepts are presented in detail in the *Concept Development Technical Report*.

5.1 Development of "Build" Corridor Conditions

To develop 2035 "Build" traffic volumes, three important components of the traffic analysis were addressed:

- Quantification of the traffic volume that diverts from local and regional roadways to I-81 based on its increased efficiency;
- Quantification of traffic diversions from I-81 to local and regional roadways due to a range of toll scenarios; and
- Quantification of traffic diversions from I-81 to rail due to railroad improvements.

The methodologies for these three components are described in the following sections. It should be noted that the following sections are discussions of projected traffic volumes only. The cross-sectional implications of these volumes (i.e. how many lanes are analyzed for DEIS concepts) are presented in subsequent sections.

5.1.1 Traffic Diverted to I-81

There often appears to be an observed increase in traffic volume that occurs soon after the opening of a new highway or the widening of a previously congested highway. However, this observation is often misinterpreted to mean that new traffic would be generated automatically as a result of an increase in highway capacity. In fact, there is general agreement among transportation planning professionals that entirely new trips represent a relatively small share of the increased traffic appearing on a new or widened highway facility.[27]

The relationship between increases in highway capacity and traffic is complex, and it is influenced by the travel behavior of the driving public, the location of residential and business properties, and changes in socioeconomic factors in the region, such as population and economic growth.

In most cases, a large number of the additional trips on a new or improved facility are trips that were already being made, albeit on other less congested facilities to the same destination, to different destinations that do not require using that roadway, or during other times of the day. The increase in traffic resulting from these cases creates the perception that the new or improved facility has created new trips; however, the increase is largely offset by reductions in traffic along parallel routes and at other times of the day. Therefore, while hourly volume totals may be different, the net effect on daily volume totals and on region-wide daily vehicle miles of travel (VMT) resulting from these travel behavior changes is minimal.

New trips may result when travelers switch from other modes, such as public transportation, to the automobile in order to take advantage of reduced travel times on the new or improved facility. In addition, new trips may result when travelers take a trip that they previously avoided altogether, because it was "too much trouble" to make under congested conditions. These two types of trips would contribute to an increase in the region-wide VMT.

The above travel behavior patterns are primarily responsible for the increases in traffic that are observed shortly after a new or widened highway facility is opened. Over the longer term, in urban areas, it is relatively rare for a highway project to provide new or substantially improved access to a large geographic area (e.g., an entire county) such that it would lead to a large increase in traffic. However, in many rural areas, increased highway capacity may improve the accessibility of one geographic area relative to other areas, making it more attractive for development.

In the I-81 corridor, which is largely rural, a large part of the traffic growth that is expected by the year 2035 can be attributed to the following three factors: projected growth (due to changes in demographic/socioeconomic factors and supported by a review of historical traffic data); diversion from parallel facilities due to the improvements to I-81; and

27 Working Together to Address Induced Demand: Proceedings of a Forum, ENO Transportation Foundation, Washington, DC, 2002, pg. 10.

increased travel that would result from injecting money into the economy and improving access to some under or undeveloped areas along the corridor.

The following sections discuss the potential for traffic diversions to and from I-81 in more detail in the context of the I-81 study area.

Potential for Traffic Diversions

The effect of diversions along the I-81 corridor was modeled using the traditional four-step travel demand process, using TP+ as the computerized travel demand program. The basis of the corridor network built for this study was the National Highway Planning Network (NHPN). The NHPN is a national database maintained by the Federal Highway Administration. For this study, detail was added to the model to show other rural roads in the corridor that provide access to I-81 and connectivity to the surrounding areas in order to estimate the diversion impacts. Given the size of the corridor, the macro level analysis produced results to be used for the purpose of comparing alternatives only. The model output, or actual numerical data, was not used to guide the conceptual design process. Detailed information regarding the modeling process for the diversion analysis can be found in the *Toll Impact Study*.

One of the benefits of improving I-81 is removing regional traffic from Route 11 and other parallel facilities along the corridor. Based on travel demand model output, the growth in traffic between the 2035 No-Build traffic volumes and the 2035 "Build" No Toll concept ranges from two to 15 percent, with the lower growth rate in the southern end of the corridor and increasing northward. As discussed in the first section of this report, some of this increase in traffic volume from 2035 No-Build to the 2035 "Build" No Toll is new trips; however, a large portion may be diverted trips that were already being made on other facilities or during other times of the day.

Traffic volume data from the model was extracted for cut lines at state and county boundaries and at additional key locations along the corridor in order to study the effect of the improvements on traffic along I-81 and other parallel facilities. The percent change in traffic on the roadways between the 2035 No-Build traffic volumes and the 2035 "Build" No Toll concept was then calculated in order to determine the extent of diversion from local roads to I-81 as a result of the improvements and increase in capacity on I-81. The diversion percentages for three county boundary cut lines are shown in Table 5-1 below, one in the southern end of the corridor (Wythe/Pulaski), one in the middle of the corridor (Botetourt/Rockbridge), and one in the northern portion of the corridor (Rockingham/Shenandoah).

Table 5-1 I-81 Diversion Estimates at County Boundaries for "Build" No Toll Scenario

	Percent Change from 2035 No-Build (Total Vehicles)	Percent Change from 2035 No-Build (Trucks)
Wythe/Pulaski County Line		
I-81	17%	26%
Hwy 42	-4%	0%
U221	-8%	-64%
Botetourt/Rockbridge County Line		
I-81	9%	19%
I-64	-13%	-39%
U220	-28%	-59%
Rockingham/Shenandoah County Line		
I-81	13%	11%
U11	-33%	-39%
Hwy 42	-14%	-33%
U211	8%	-33%
U340	-18%	-12%

Note: These percentages should only be viewed as reflections of change, not in projected traffic volume, as the modeling was conducted at the macro level and for comparison purposes only. The percentages tend to be higher on the smaller facilities as differences in smaller umbers can be more dramatic when expressed as a percentage change.

At all three locations, there is an increase in traffic on I-81, with a corresponding decrease in traffic on nearby parallel facilities, as vehicles divert to I-81 to take advantage of the improved traffic operations. Generally, in locations with higher populations and traffic volumes, the diversion percentages are greater as traffic shifts from one facility to another due to the additional capacity on I-81. In more rural areas, the effects are smaller as the capacity before the improvements may have been sufficient to accommodate demand and users were already using the appropriate facility to complete their trip. This trend can be seen in the table above; the percentages generally increase from south to north, just as population and traffic volumes increase from south to north along the corridor.

The roadways included in the cut lines are those that are considered the primary alternate routes to I-81. However, in some of the more populated areas, such as the Blacksburg/Christiansburg/Roanoke area, Harrisonburg, and Winchester, other alternate routes may be available as well. In these areas, a considerable shift in traffic from facility to facility can be expected as additional capacity is made available on I-81.

Economic Development Contributing To Increased Travel

Techniques to quantify the extent of increased travel due to economic development are still in development stages and research has yet to provide definitive estimates of its impacts.

However, it is generally accepted that transportation infrastructure improvements may over the long run create demand as a result of increased development. Thus, it can be deduced that the injection of money into the economy with the I-81 widening would result in some amount of increased traffic in the region. To what extent is unknown; however, the areas in which the effects may be observed are briefly discussed below.

Increase in Population and Employment

Economic development policies for cities and towns are often oriented toward stimulating employment growth. The emphasis on job creation is particularly strong in rural communities. On the City of Harrisonburg's economic development web page and on its official website, there are two slogans: "The Friendly City" and "The City with the Planned Future." Both slogans were developed to describe their commitment to supporting local business and inviting new business investment.

In all likelihood, most of the small cities and towns that I-81 serves have the same goal to attract more business. To that end, an improved I-81 may serve to reach that goal, which would in turn attract more people, and it would also improve travel conditions for cross-county commuters to potential new jobs. Of course, the opposite may also hold true. A large part of the area has a significantly lower income than the rest of the Commonwealth and a road toll tax, if imposed, may deter such growth.

Increase in Freight Movement

Economies in the I-81 corridor rely heavily on the truck freight systems that move manufacturing products to their destinations. I-81 is a major trucking corridor since it connects Canada and the more densely populated northeastern United States to the mid-southern states and provides connection to other routes to the Texas-Mexico border. Virginia's portion of I-81 is critical to overall national system linkage, with connections to three major interstate highways, including:

- I-77 in Wytheville, Virginia
- I-64 near Lexington and Staunton, Virginia
- I-66 near Middletown, Virginia

The passage of the North American Free Trade Agreement (NAFTA) over a decade ago has increased cross-border trade and subsequent truck-hauled freight moving to and from the northeastern metropolitan regions. The fact that few other interstate corridors offer such a southwest-to-northeast alignment on the east coast and that it avoids the congestion around the major cities along the east coast adds to its attractiveness as a truck route.

The economies of many of the cities and towns located along I-81 rely on the interstate for their growth and success. For example, Virginia's official website states that one of the greatest facilitators to Bristol's economic growth through the years has been its accessibility and well-organized transportation connections. The City of Bristol is located within a day's drive of more than 70 percent of the U.S. population, and it is served by more than 50 motor freight carriers and two railroads. Similarly, the Roanoke Valley Economic Development Partnership website boasts that the Roanoke Valley offers excellent market access, thanks to a foreign trade zone and inland port, a jet-served airport, and I-81.

Thus, the improvement of the I-81 corridor may attract additional truck traffic and commercial development that would otherwise not happen if the corridor remained as it is today.

Increase in Tourism

The I-81 corridor, rich in scenic and cultural resources, is also a major tourism corridor. The AAA (the American Automobile Association) voted I-81 as one of the top ten most scenic interstates in the United States. An estimated $1.7 billion dollars is expended annually in the corridor by visitors. These visitors are attracted by recreational opportunities in the Shenandoah and Blue Ridge Mountains, the rich civil war history, and the numerous attractions in the 13 counties along its path.

As with the other areas of growth projected along the corridor, it can be expected that additional traffic due to tourism may be generated due to the improvements to the I-81 corridor.

"Build" No Toll Traffic Volumes

The "Build" No Toll traffic volumes are those expected on an improved I-81that does not charge a toll to vehicles. The analysis detailed above results in a shift of traffic from local and regional roads to I-81 on the order of two to 15 percent, with the higher diversions occurring in the north. Much of this traffic is diverted from local parallel routes, however, it is assumed that a regional/national percentage of traffic is diverted from parallel interstates (such as I-95, I-85, I-64, I-65, I-70, and I-79) and a percentage are new trips. As such, the 2035 "Build" No Toll traffic volumes were created by growing the 2035 No-Build volumes (discussed in Chapter 4) appropriately based on location. It is from this base "Build" condition that all tolling and freight diversions are taken. Figure 5-1 presents the "Build" No Toll traffic volumes.

5.1.2 Diversions Due to Tolls

A full discussion of toll modeling, methodology, and results is provided in the *Toll Impact Study*. The following summarizes the procedures used. The effect of tolls was also studied to determine the relative impacts to local communities as vehicles may divert from I-81 to avoid the toll. Under the Build concepts, various tolling schemes were tested including a No Toll Option, Low Toll and High Toll Options for all vehicles, and Low Toll and High Toll options for trucks only. The values used for the tolling options are shown below:

- Low Toll - $0.08 per mile/vehicle car, $0.04 per mile/axle truck
- High Toll - $0.14 per mile/vehicle car, $0.07 per mile/axle truck
- Low Toll Commercial Vehicles - $0.04 per mile/axle truck
- High Toll Commercial Vehicles - $0.07 per mile/axle truck

The process of 'modeling' a toll scheme in a travel demand model is done by converting the toll cost per mile into an equivalent time penalty. This additional perceived time by the toll user is then added to the total travel time on I-81 in order to influence whether or not the user is willing to find a competing route on an alternate toll-free facility that offers a competitive travel time. The primary piece of data required for this conversion is an estimate of the facility user's value of time. The higher a user's value of time, the less likely they are to divert from the faster, more direct route as delays would be more costly. The values of time used for the I-81 study are shown below:

- Passenger Car Value of Time: $15 per hour
- Truck Value of Time: $60 per hour

A summary of the amount of toll diversion off of I-81 onto alternative routes is shown below in Table 5-2, followed by the diversion estimates for the three specific county boundaries shown above. These diversion percentages were calculated by comparing the volume of traffic using the facilities for the various toll alternatives with the 2035 "Build" No Toll concept.

Table 5-2 I-81 Summary of Diversion Estimates due to Tolls

			Commercial Vehicles Only	
	Low Toll	High Toll	Low Toll	High Toll
Total Vehicles				
Average Diversion[1] from I-81	8%	16%	2%	9%
Trucks				
Average Diversion[1] from I-81	3%	11%	12%	25%

1 The smallest vehicle diversion from I-81 at any point along the corridor.
2 The largest vehicle diversion from I-81 expected at any point along the corridor.
3 The average vehicle diversion for all of I-81 in Virginia. Diversions vary widely throughout the corridor. Therefore, the average diversion is not the mean of minimum and maximum diversions noted.

As shown in the summary table, vehicles divert from I-81 due to the implementation of tolls. The percentage of vehicles diverting from I-81 nearly doubles from the Low Toll Option to the High Toll Option. With the Low Toll for commercial vehicles only, the diversion estimates for total vehicles are fairly minor as passenger cars, which make up most of the traffic stream, would not be affected by the toll, thus less likely to divert. However, there are high percentage maximum diversion for trucks with the Toll Options for only commercial vehicles. These high percentages can be explained by the fact that with this option, as there is no toll penalty for passenger cars, most of the additional capacity on I-81 is filled by those vehicles. As a result, trucks are more likely to divert to find a shorter path.

Table 5-32035 I-81 Diversion Estimates at County Boundaries Due to Tolls

	Toll All Vehicles				Toll Commercial Vehicles Only			
	Low Toll		High Toll		Low Toll		High Toll	
	Total Vehicles	Trucks	Total Vehicles	Trucks	Total Vehicles	Trucks	Total Vehicles	Trucks
Wythe/Pulaski County Line								
I-81	-8%	-3%	-18%	-11%	-3%	-11%	-5%	-21%
Hwy 42	5%	0%	17%	0%	0%	0%	0%	0%
U221	6%	61%	14%	85%	2%	93%	5%	210%
Botetourt/Rockbridge County Line								
I-81	-5%	-4%	-12%	-10%	-1%	-10%	-3%	-18%
I-64	9%	24%	20%	20%	5%	56%	8%	76%
U220	30%	18%	42%	99%	11%	127%	15%	170%
Rockingham/Shenandoah County Line								
I-81	-10%	-3%	-15%	15%	-2%	-15%	-5%	-43%
U11	43%	-6%	63%	-32%	25%	275%	44%	377%
Hwy 42	38%	50%	40%	150%	-1%	50%	3%	200%
U211	-15%	25%	-14%	75%	-1%	50%	1%	100%
U340	16%	157%	28%	86%	0%	225%	1%	250%

Note: These percentages should only be viewed as reflections of change, not in projected traffic volume, as the modeling was conducted at the macro level and for comparison purposes only. The percentages tend to be higher on the smaller facilities as differences in smaller numbers can be more dramatic when expressed as a percentage change.

In Table 5-3, which provides the diversion estimates at three county boundaries for I-81, it can be seen to what extent vehicles would divert to parallel facilities in order to avoid the toll. With only a few exceptions, traffic volumes increase on the primary parallel roadways. It should be noted that the reduction in traffic on I-81 and the increase in traffic on the parallel facilities should not be considered one for one. The effect of tolls may also be that some trips are not taken at all now or that they are taken to different destinations that do not require the use of I-81 or its parallel facilities. Truck diversion percentages are particularly high at some locations; their higher value of time within the model requires that they be reassigned within the roadway network in order to find the shortest, most cost-effective path to their destination. Initially, there may be a back-and-forth type of effect on the corridor and volumes would fluctuate; however, with time, equilibrium would be reached as regular users would become familiar with corridor operations and plan their trip accordingly.

“Build” with Toll Traffic Volumes

The “Build” with toll traffic volumes represent 2035 traffic volumes expected on an improved I-81 that includes toll fees. This analysis results in a shift of traffic from I-81 back to un-tolled, parallel local and interstate routes. Four additional traffic networks were created for these scenarios – “Build” Low Toll, “Build” High Toll, “Build” Low Toll for commercial vehicles, and “Build” High Toll for commercial vehicles. These four networks are calculated by subtracting the toll diversions from the 2035 “Build” No Toll traffic volumes. Figures 5-2 through 5-5 present the traffic volumes associated with these four scenarios.

5.1.3 Freight to Rail Diversion Analysis Results

The methodology and detailed freight diversion analysis is presented in its entirety in the *Freight Forecast and Diversion Technical Report*. The results of the analysis are provided in Table 5-4 using the Uniform Rail Costing System (URCS) Plan 1.0 estimates for rail line haul variable costs. Variable costs are defined by the Federal Highway Administration Office of Policy as costs incurred before a “contribution to their capital infrastructure and profit.” The model calibrated after rail line haul costs were raised by 35 percent above the variable cost. From the analysis, it is estimated that 147,000 to 1,259,100 annual (2035) truck trips can be diverted to rail, based on the rail improvement tested.

“Build” with Rail Diversions

Freight traffic shifting from truck to rail provides an additional reduction in truck traffic along the corridor. Separate traffic volume networks were created for the four rail improvement options studied (identified in the *Concept Development Technical Report*). These networks were tested on their own, and in combination with the toll scenarios. Toll scenarios were evaluated in conjunction with the rail concepts even though by federal law, no toll revenue could be collected on I-81 and used to fund rail improvements. This evaluation was conducted for informational purposes and to confirm that Rail Concept 3 was the proper selection for use in combination with other concepts. The rail 3 option was identified as being the best cost-benefit reduction along I-81. Therefore, this option was further tested as a component of all concepts looked at. Figures 5-6 through 5-10 present the traffic volumes for the various toll scenarios with the inclusion of projected Rail 3 traffic diversions.

Table 5-4 Analysis Results - Mode Diversions From Truck to Rail

	No Build	Rail 1 Star Solutions	Rail 2 Reebie - Piedmont Line	Rail 3 NSRR Pilot Intermodal	Rail 4 Steel Interstate
Truck Assumptions					
Speed (mph)	43	43	43	43	43
Transit Time Reliability[1]	0.42	0.42	0.42	0.42	0.42
Toll	$0.00	$0.00	$0.00	$0.00	$0.00
Rail Assumptions					
Speed (mph)	22.5	24.8	28.1	33.0	40.0
Transit Time Reliability[1]	0.45	0.44	0.43	0.42	0.38
Investment Recovery[2] (per hundredweight)	$0.00	$0.00	$0.14	$0.14	$0.02
Load/Unload Time (hours)	0.57	0.57	0.15	0.15	0.15
Truck Trailer Equipment Lease Rate	$20/day	$20/day	$20/day	$20/day	$20/day
Drayage Charge (base)	$340.00	$340.00	$340.00	$340.00	$340.00
Drayage Distance (miles)	80	80	80	80	80
Drayage Charge/Mile	$2.00	$2.00	$2.00	$2.00	$2.00
Infrastructure Investment (Mil)	$0.0	$111.0	$267.0	$280.0	$3,200.0
Rolling Stock Investment (Mil)	$0.0	$0.0	$229.0	$229.0	$300.00
URCS Estimate Method	Plan 1.0+35%	Plan 1.0+35%	Plan 1.0+15%	Plan 1.0+15%	Plan 1.0+15%
Diversion of >500 Mile Trips					
2035 >500 Mile Truck Trips (000)	7,363.8	7,363.8	7,363.8	7,363.8	7,363.80
2035 Diverted Truck Trips (000)	107.2	147.1	606.4	744.8	1,224.5
Percent Diverted	1.5%	2.0%	8.2%	10.1%	16.60%
Diversion of All Trips					
2035 Total Truck Trips (000)[3]	21,031.2	21,031.2	21,031.2	21,031.2	21,031.2
2035 Diverted Truck Trips (000)	107.2	147.1	606.4	744.8	1,224.5
Percent Diverted	0.5%	0.7%	2.9%	3.5%	5.8%

1 Reliability is a factor equal to standard deviation of transit time divided by mean transit time, lower value improves reliability.
2 Investment recovery is a fee expressed in dollars per hundredweight.
3 Expressed in millions. Represents an estimate based on the 2035 No-Build Truck Trip Estimates.

5.2 Tier 1 DEIS Evaluation

The *Concept Development Technical Report* and Chapter 3 of the *Tier 1 DEIS* present the 211 "Build" concepts evaluated as part of the traffic analysis. Each of the concepts identified for evaluation was tested with the traffic volumes identified above. With respect to transportation evaluation, there are three assumptions globally inherent in all Tier 1 DEIS improvement concepts:

- The concepts consider planned roadway improvements at the Tennessee and West Virginia state lines and provide adequate distance for transition;
- All Tier 1 DEIS improvement concepts include TSM improvements; and
- All Tier 1 DEIS improvement concepts consider induced traffic.

With these assumptions in mind, the No-Build and 211 "Build" concepts were evaluated against the criteria defined below.

Levels of Service

Each concept is evaluated based upon its potential to improve Level of Service along the interstate. The level of service application and designation are based on the methodologies outlined in the Highway Capacity Manual, as described in detail in Chapter 3, Analysis of Existing Conditions. The level of service standards that must be achieved are in accordance with AASHTO guidelines (also described in Chapter 3).

Secondary Impacts on U.S. Route 11

Highway corridors that run parallel to I-81, the most prominent of which is Route 11, are likely to experience some effects from improvements on I-81. With an improved I-81, traffic might divert to the interstate to ease their trip. With tolls along I-81, motorists might make different route choices to avoid paying tolls. These potential effects to Route 11 were tested for each "Build" concept and the consequences evaluated. (See Section 5-4, Results of Traffic Impact Analysis on U.S. Route 11).

Toll Effects

Implementation of tolls along I-81 is under consideration to help fund the various "Build" concepts being considered. These tolls have the potential to divert some traffic onto alternate routes. Alternative toll scenarios are analyzed from two perspectives: 1) as a component of the "Build" concepts to demonstrate the additional capacity each could create along I-81, and 2) as secondary impacts to assess the effects that they might have on alternate routes along the I-81 corridor. (See Section 5.4, Results of Traffic Impact Analysis on U.S. Route 11.)

Safety

Crash statistics for a recent three-year period along I-81 revealed 5,746 reported crashes along the corridor. Seventy-one (71) of these crashes involved fatalities and 2,098 crashes (36.5 percent) involved personal injury to 3,095 persons. Each concept is evaluated on its effect on safety conditions along the corridor including the potential to reduce crashes and the risk of injury. (See Section 5.5, Safety Effects.)

Costs

Conceptual cost estimates were completed for each concept. (See Sections 5.3, DEIS Analysis Results.)

5.3 DEIS Analysis Results

Table 5-5 provides a summary of the traffic operational results of the No-Build and 211 "Build" concepts considered. This summary provides the costs of each concept along with the miles of mainline expected to operate at a deficient level of service under the "Build" concept. Also provided are the miles of excess capacity expected under the "Build" concept.

5.3.1 Tier 1 Findings

The following section addresses the concepts' ability to meet the safety and capacity needs identified in Chapter 2 of the Tier 1 DEIS (Purpose and Need).

TSM and Stand Alone Rail Concepts

The evaluation results indicate that demand can not be reduced sufficiently (either through tolling, a shift to rail, or a combination of the two) such that widening I-81 would become unnecessary. Similarly, it was determined that TSM alone was not a sufficient option.
As explained previously, the Rail 3 option was identified as being the best cost-benefit reduction along I-81, therefore Rail 1, 2, and 4 improvements were not analyzed in combination with other alternatives.

Table 5-5 Transportation Analysis Results

Non-Separated Facilities																
	Operational Assumptions						Operational Results (Exclusive Car Lanes)		Operational Results (Exclusive Truck Lanes)		Operational Results (Non-Exclusive Truck Lanes)		Operational Results (General Purpose Lanes)			
	No Toll	Low Toll All	High Toll All	Low Toll Comm	High Toll Comm	With R3[5]	Deficient Miles[6]	Excess Miles[6]	Deficient Miles[6]	Excess Miles[6]	Deficient Miles[6]	Excess Miles[6]	Deficient Miles[6]	Excess Miles[6]	2005 Cost	2015 Cost
No-Build																
	✓						N/A	N/A	N/A	N/A	N/A	N/A	594	18		
TSM[1]																
	✓						N/A	N/A	N/A	N/A	N/A	N/A	594	18	$0.08 B	$0.1 B
Highway																
Add 1 lane in each direction	✓						N/A	N/A	N/A	N/A	N/A	N/A	396	37		
6 to 8-lane cross-section		✓					N/A	N/A	N/A	N/A	N/A	N/A	325	89		
			✓				N/A	N/A	N/A	N/A	N/A	N/A	237	131	$5.1 B	$7.5 B
				✓			N/A	N/A	N/A	N/A	N/A	N/A	378	68		
					✓		N/A	N/A	N/A	N/A	N/A	N/A	364	104		
Combination Concept 1	✓					✓	N/A	N/A	N/A	N/A	N/A	N/A	378	67		
Add 1 lane in each direction		✓				✓	N/A	N/A	N/A	N/A	N/A	N/A	294	99		
In combination with Rail 3			✓			✓	N/A	N/A	N/A	N/A	N/A	N/A	169	150	$5.6 B	$8.2 B
				✓		✓	N/A	N/A	N/A	N/A	N/A	N/A	328	75		
					✓	✓	N/A	N/A	N/A	N/A	N/A	N/A	285	122		
Add 2 lanes in each direction	✓						N/A	N/A	N/A	N/A	N/A	N/A	76	254		
Results in 8 to 10 –lane		✓					N/A	N/A	N/A	N/A	N/A	N/A	51	325		
Cross-section			✓				N/A	N/A	N/A	N/A	N/A	N/A	20	413	$7.8 B	$11.4 B
				✓			N/A	N/A	N/A	N/A	N/A	N/A	62	272		
					✓		N/A	N/A	N/A	N/A	N/A	N/A	61	286		
Combination Concept 2	✓					✓	N/A	N/A	N/A	N/A	N/A	N/A	59	272		
Add 2 lanes in each direction		✓				✓	N/A	N/A	N/A	N/A	N/A	N/A	30	356		
In Combination with Rail 3			✓			✓	N/A	N/A	N/A	N/A	N/A	N/A	1	481	$8.3 B	12.2 B
				✓		✓	N/A	N/A	N/A	N/A	N/A	N/A	62	322		
					✓	✓	N/A	N/A	N/A	N/A	N/A	N/A	33	365		

Table 5-5 Transportation Analysis Results (Continued)

Non-Separated Facilities	Operational Assumptions						Operational Results (Exclusive Car Lanes)		Operational Results (Exclusive Truck Lanes)		Operational Results (Non-Exclusive Truck Lanes)		Operational Results (General Purpose Lanes)			
	No Toll	Low Toll All	High Toll All	Low Toll Comm	High Toll Comm	With R3[5]	Deficient Miles[6]	Excess Miles[6]	Deficien t Miles[6]	Excess Miles[6]	Deficient Miles[6]	Excess Miles[6]	Deficient Miles[6]	Excess Miles[6]	2005 Cost	2015 Cost
Add 3 lanes in each direction	✓						N/A	N/A	N/A	N/A	N/A	N/A	0	574		
Results in 10 to 12-lane		✓					N/A	N/A	N/A	N/A	N/A	N/A	0	599		
cross-section			✓				N/A	N/A	N/A	N/A	N/A	N/A	0	630	$11.2 B	$16.4 B
				✓			N/A	N/A	N/A	N/A	N/A	N/A	0	588		
					✓		N/A	N/A	N/A	N/A	N/A	N/A	0	599		
Combination Concept 3	✓					✓	N/A	N/A	N/A	N/A	N/A	N/A	0	591		
Add 3 lanes in each direction		✓				✓	N/A	N/A	N/A	N/A	N/A	N/A	0	620		
In combination with Rail 3			✓			✓	N/A	N/A	N/A	N/A	N/A	N/A	0	649	$11.7 B	$17.1 B
				✓		✓	N/A	N/A	N/A	N/A	N/A	N/A	0	588		
					✓	✓	N/A	N/A	N/A	N/A	N/A	N/A	0	617		
Uniform 6-lane cross-section	✓						N/A	N/A	N/A	N/A	N/A	N/A	411	24		
(Add 1 lane in each direction		✓					N/A	N/A	N/A	N/A	N/A	N/A	339	75		
except in Bristol and			✓				N/A	N/A	N/A	N/A	N/A	N/A	242	108	$4.9 B	$7.2 B
Wytheville)				✓			N/A	N/A	N/A	N/A	N/A	N/A	392	54		
					✓		N/A	N/A	N/A	N/A	N/A	N/A	372	84		
Combination 4	✓					✓	N/A	N/A	N/A	N/A	N/A	N/A	393	54		
Uniform 6 –lane cross-section		✓				✓	N/A	N/A	N/A	N/A	N/A	N/A	306	83		
In combination with Rail 3			✓			✓	N/A	N/A	N/A	N/A	N/A	N/A	174	127	$5.4 B	$7.9 B
				✓		✓	N/A	N/A	N/A	N/A	N/A	N/A	393	54		
					✓	✓	N/A	N/A	N/A	N/A	N/A	N/A	290	101		

Table 5-5 Transportation Analysis Results (Continued)

Non-Separated Facilities																
	Operational Assumptions						Operational Results (Exclusive Car Lanes)		Operational Results (Exclusive Truck Lanes)		Operational Results (Non-Exclusive Truck Lanes)		Operational Results (General Purpose Lanes)			
	No Toll	Low Toll All	High Toll All	Low Toll Comm	High Toll Comm	With R3[5]	Deficient Miles[6]	Excess Miles[6]	Deficient Miles[6]	Excess Miles[6]	Deficient Miles[6]	Excess Miles[6]	Deficient Miles[6]	Excess Miles[6]	2005 Cost	2015 Cost
Uniform 8-lane cross-section	✓						N/A	N/A	N/A	N/A	N/A	N/A	76	239		
(Add 2 lanes in each		✓					N/A	N/A	N/A	N/A	N/A	N/A	51	311		
direction, but add 1 lane in			✓				N/A	N/A	N/A	N/A	N/A	N/A	20	408	$7.5 B	$11.0 B
Bristol and Wytheville)				✓			N/A	N/A	N/A	N/A	N/A	N/A	62	258		
					✓		N/A	N/A	N/A	N/A	N/A	N/A	61	278		
Combination Concept 4	✓					✓	N/A	N/A	N/A	N/A	N/A	N/A	59	257		
Uniform 8-lane cross-section		✓				✓	N/A	N/A	N/A	N/A	N/A	N/A	30	344		
In combination with Rail 3			✓			✓	N/A	N/A	N/A	N/A	N/A	N/A	1	476	$8.0 B	$11.7 B
				✓		✓	N/A	N/A	N/A	N/A	N/A	N/A	62	257		
					✓	✓	N/A	N/A	N/A	N/A	N/A	N/A	33	360		
Rail																
Rail 1 (R1)[2]	✓						N/A	N/A	N/A	N/A	N/A	N/A	604	4		
		✓					N/A	N/A	N/A	N/A	N/A	N/A	540	8		
			✓				N/A	N/A	N/A	N/A	N/A	N/A	480	42	$0.1 B	$0.2 B
				✓			N/A	N/A	N/A	N/A	N/A	N/A	579	4		
					✓		N/A	N/A	N/A	N/A	N/A	N/A	539	8		
Rail 2 (R2)[3]	✓						N/A	N/A	N/A	N/A	N/A	N/A	594	46		
		✓					N/A	N/A	N/A	N/A	N/A	N/A	530	110		
			✓				N/A	N/A	N/A	N/A	N/A	N/A	439	170	$0.5 B	$0.7 B
				✓			N/A	N/A	N/A	N/A	N/A	N/A	575	71		
					✓		N/A	N/A	N/A	N/A	N/A	N/A	528	111		

Table 5-5 Transportation Analysis Results (Continued)

Non-Separated Facilities															
	Operational Assumptions						Operational Results (Exclusive Car Lanes)		Operational Results (Exclusive Truck Lanes)		Operational Results (Non-Exclusive Truck Lanes)		Operational Results (General Purpose Lanes)			
	No Toll	Low Toll All	High Toll All	Low Toll Comm	High Toll Comm	With R3[5]	Deficient Miles[6]	Excess Miles[6]	Deficient Miles[6]	Excess Miles[6]	Deficient Miles[6]	Excess Miles[6]	Deficient Miles[6]	Excess Miles[6]	2005 Cost	2015 Cost
Rail 3 (R3)[5]	✓						N/A	N/A	N/A	N/A	N/A	N/A	583	56		
		✓					N/A	N/A	N/A	N/A	N/A	N/A	551	120		
			✓				N/A	N/A	N/A	N/A	N/A	N/A	500	211		
				✓			N/A	N/A	N/A	N/A	N/A	N/A	583	75		
					✓		N/A	N/A	N/A	N/A	N/A	N/A	528	122	$0.5 B	$0.7 B
Rail 4 (R4)[4]	✓						N/A	N/A	N/A	N/A	N/A	N/A	572	67		
		✓					N/A	N/A	N/A	N/A	N/A	N/A	503	99		
			✓				N/A	N/A	N/A	N/A	N/A	N/A	396	150		
				✓			N/A	N/A	N/A	N/A	N/A	N/A	553	67		
					✓		N/A	N/A	N/A	N/A	N/A	N/A	522	122	$3.7 B	$5.4 B

Table 5-5 Transportation Analysis Results (Continued)

Separated Facilities	Operational Assumptions						Operational Results (Exclusive Car Lanes)		Operational Results (Exclusive Truck Lanes)		Operational Results (Non-Exclusive Truck Lanes)		Operational Results (General Purpose Lanes)			
	No Toll	Low Toll All	High Toll All	Low Toll Comm	High Toll Comm	With R3[5]	Deficient Miles[2]	Excess Miles[2]	Deficient Miles[2]	Excess Miles[2]	Deficient Miles[2]	Excess Miles[2]	Deficient Miles[2]	Excess Miles[2]	2005 Cost	2015 Cost
Separated Lane Concept 1[7]																
Add one exclusive truck lane in	✓						14	302	384	0	N/A	N/A	N/A	N/A	$11.2B	$16.4 B
each direction plus one		✓					5	439	371	0	N/A	N/A	N/A	N/A	$11.2B	$16.4 B
exclusive car lane in each			✓				1	482	237	0	N/A	N/A	N/A	N/A	$11.2B	$16.4 B
direction				✓			14	302	294	0	N/A	N/A	N/A	N/A	$11.2B	$16.4 B
					✓		14	302	257	0	N/A	N/A	N/A	N/A	$11.2B	$16.4 B
Results in 8- to 10-lane	✓					✓	14	302	291	0	N/A	N/A	N/A	N/A	$11.7B	$17.1 B
cross-section		✓				✓	5	439	264	0	N/A	N/A	N/A	N/A	$11.7B	$17.1 B
			✓			✓	1	482	191	0	N/A	N/A	N/A	N/A	$11.7B	$17.1 B
				✓		✓	14	302	217	0	N/A	N/A	N/A	N/A	$11.7B	$17.1 B
					✓	✓	14	302	199	0	N/A	N/A	N/A	N/A	$11.7B	$17.1 B
(Add one exclusive truck lane in	✓						0	636	384	0	N/A	N/A	N/A	N/A	$12.2B	$17.9 B
each direction plus two		✓					0	645	371	0	N/A	N/A	N/A	N/A	$12.2B	$17.9 B
exclusive car lane in each			✓				0	649	237	0	N/A	N/A	N/A	N/A	$12.2B	$17.9 B
direction				✓			0	636	294	0	N/A	N/A	N/A	N/A	$12.2B	$17.9 B
					✓		0	636	257	0	N/A	N/A	N/A	N/A	$12.2B	$17.9 B
Results in 10- to 12-lane	✓					✓	0	636	291	0	N/A	N/A	N/A	N/A	$12.7B	$18.6 B
cross-section		✓				✓	0	645	264	0	N/A	N/A	N/A	N/A	$12.7B	$18.6 B
			✓			✓	0	649	191	0	N/A	N/A	N/A	N/A	$12.7B	$18.6 B
				✓		✓	0	636	217	0	N/A	N/A	N/A	N/A	$12.7B	$18.6 B
					✓	✓	0	636	199	0	N/A	N/A	N/A	N/A	$12.7B	$18.6 B

Table 5-5 Transportation Analysis Results (Continued)

Separated Facilities																
	Operational Assumptions						Operational Results (Exclusive Car Lanes)		Operational Results (Exclusive Truck Lanes)		Operational Results (Non-Exclusive Truck Lanes)		Operational Results (General Purpose Lanes)			
	No Toll	Low Toll All	High Toll All	Low Toll Trucks	High Toll Trucks	With R3[5]	Deficient Miles[2]	Excess Miles[2]	Deficient Miles[2]	Excess Miles[2]	Deficient Miles[2]	Excess Miles[2]	Deficient Miles[2]	Excess Miles[2]	2005 Cost	2015 Cost
Separated Lane Concept 2[7]																
	✓						348	22	65	266	N/A	N/A	N/A	N/A	$11.2B	$16.4 B
Add two exclusive truck lanes		✓					211	69	53	279	N/A	N/A	N/A	N/A	$11.2B	$16.4 B
In each direction.			✓				168	90	40	413	N/A	N/A	N/A	N/A	$11.2B	$16.4 B
				✓			348	22	42	356	N/A	N/A	N/A	N/A	$11.2B	$16.4 B
Results in 8- to 10-lane					✓		348	22	36	393	N/A	N/A	N/A	N/A	$11.2B	$16.4 B
cross-section	✓					✓	348	22	42	359	N/A	N/A	N/A	N/A	$11.7B	$17.1 B
		✓				✓	211	69	21	386	N/A	N/A	N/A	N/A	$11.7B	$17.1 B
			✓			✓	168	90	0	459	N/A	N/A	N/A	N/A	$11.7B	$17.1 B
				✓		✓	348	22	10	433	N/A	N/A	N/A	N/A	$11.7B	$17.1 B
					✓	✓	348	22	0	451	N/A	N/A	N/A	N/A	$11.7B	$17.1 B
Add two exclusive truck lanes	✓						14	302	65	266	N/A	N/A	N/A	N/A	$12.2B	$17.9 B
In each direction plus one		✓					5	439	53	279	N/A	N/A	N/A	N/A	$12.2B	$17.9 B
exclusive car lane in each			✓				1	402	40	413	N/A	N/A	N/A	N/A	$12.2B	$17.9 B
direction				✓			14	302	42	356	N/A	N/A	N/A	N/A	$12.2B	$17.9 B
					✓		14	302	36	393	N/A	N/A	N/A	N/A	$12.2B	$17.9 B
Results in 10- to 12-lane	✓					✓	14	302	42	359	N/A	N/A	N/A	N/A	$12.7B	$18.6 B
cross-section		✓				✓	5	439	21	386	N/A	N/A	N/A	N/A	$12.7B	$18.6 B
			✓			✓	1	402	0	459	N/A	N/A	N/A	N/A	$12.7B	$18.6 B
				✓		✓	14	302	10	433	N/A	N/A	N/A	N/A	$12.7B	$18.6 B
					✓	✓	14	302	0	451	N/A	N/A	N/A	N/A	$12.7B	$18.6 B

Table 5-5 Transportation Analysis Results (Continued)

	Separated Facilities															
	Operational Assumptions						Operational Results (Exclusive Car Lanes)		Operational Results (Exclusive Truck Lanes)		Operational Results (Non-Exclusive Truck Lanes)		Operational Results (General Purpose Lanes)			
	No Toll	Low Toll All	High Toll All	Low Toll Trucks	High Toll Trucks	With R3[5]	Deficient Miles[2]	Excess Miles[2]	Deficient Miles[2]	Excess Miles[2]	Deficient Miles[2]	Excess Miles[2]	Deficient Miles[2]	Excess Miles[2]	2005 Cost	2015 Cost
Separated Lane Concept 2[7]																
	✓						0	636	65	266	N/A	N/A	N/A	N/A	$12.5B	$18.3 B
		✓					0	645	53	279	N/A	N/A	N/A	N/A	$12.5B	$18.3 B
Add two exclusive truck lanes			✓				0	649	40	413	N/A	N/A	N/A	N/A	$12.5B	$18.3 B
In each direction plus two				✓			0	636	42	356	N/A	N/A	N/A	N/A	$12.5B	$18.3 B
exclusive car lanes in each					✓		0	636	36	393	N/A	N/A	N/A	N/A	$12.5B	$18.3 B
direction	✓					✓	0	636	42	359	N/A	N/A	N/A	N/A	$13.0B	$19.0 B
		✓				✓	0	645	21	386	N/A	N/A	N/A	N/A	$13.0B	$19.0 B
Results in 12- to 14-lane			✓			✓	0	649	0	459	N/A	N/A	N/A	N/A	$13.0B	$19.0 B
cross-section				✓		✓	0	636	10	433	N/A	N/A	N/A	N/A	$13.0B	$19.0 B
					✓	✓	0	636	0	451	N/A	N/A	N/A	N/A	$13.0B	$19.0 B
Separated Lane Concept 3[8]																
	✓						N/A	N/A	N/A	N/A	10	422	495	10	$9.3B	$13.6 B
Add two non-exclusive truck		✓					N/A	N/A	N/A	N/A	0	425	335	19	$9.3B	$13.6 B
lanes in each direction.			✓				N/A	N/A	N/A	N/A	0	494	266	69	$9.3B	$13.6 B
				✓			N/A	N/A	N/A	N/A	0	453	452	12	$9.3B	$13.6 B
Results in 8- to 10-lane					✓		N/A	N/A	N/A	N/A	0	478	440	12	$9.3B	$13.6 B
cross-section	✓					✓	N/A	N/A	N/A	N/A	0	460	452	12	$9.8B	$14.4 B
		✓				✓	N/A	N/A	N/A	N/A	0	468	335	22	$9.8B	$14.4 B
			✓			✓	N/A	N/A	N/A	N/A	0	494	240	74	$9.8B	$14.4 B
				✓		✓	N/A	N/A	N/A	N/A	0	529	424	12	$9.8B	$14.4 B
					✓	✓	N/A	N/A	N/A	N/A	0	556	413	13	$9.8B	$14.4 B

Table 5-5 Transportation Analysis Results (Continued)

Separated Facilities															
	Operational Assumptions						Operational Results (Exclusive Car Lanes)		Operational Results (Exclusive Truck Lanes)		Operational Results (Non-Exclusive Truck Lanes)		Operational Results (General Purpose Lanes)			
	No Toll	Low Toll All	High Toll All	Low Toll Trucks	High Toll Trucks	With R3[5]	Deficient Miles[2]	Excess Miles[2]	Deficient Miles[2]	Excess Miles[2]	Deficient Miles[2]	Excess Miles[2]	Deficient Miles[2]	Excess Miles[2]	2005 Cost	2015 Cost
Separated Lane Concept 3[8]																
	✓						N/A	N/A	N/A	N/A	10	422	64	155	$9.9B	$14.5 B
		✓					N/A	N/A	N/A	N/A	0	425	18	315	$9.9B	$14.5 B
Add two non-exclusive truck			✓				N/A	N/A	N/A	N/A	0	494	10	384	$9.9B	$14.5 B
lanes in each direction plus				✓			N/A	N/A	N/A	N/A	0	453	62	198	$9.9B	$14.5 B
one general purpose lane in					✓		N/A	N/A	N/A	N/A	0	478	59	210	$9.9B	$14.5 B
each direction.	✓					✓	N/A	N/A	N/A	N/A	0	460	62	198	$10.4B	$15.2 B
		✓				✓	N/A	N/A	N/A	N/A	0	468	11	315	$10.4B	$15.2 B
Results in 10- to 12-lane			✓			✓	N/A	N/A	N/A	N/A	0	494	9	410	$10.4B	$15.2 B
cross-section				✓		✓	N/A	N/A	N/A	N/A	0	529	57	226	$10.4B	$15.2 B
					✓	✓	N/A	N/A	N/A	N/A	0	556	47	237	$10.4B	$15.2 B
Add two non-exclusive truck	✓						N/A	N/A	N/A	N/A	10	422	0	586	$10.3B	$15.1 B
lanes in each direction plus		✓					N/A	N/A	N/A	N/A	0	425	0	632	$10.3B	$15.1 B
two general purpose lanes			✓				N/A	N/A	N/A	N/A	0	494	0	640	$10.3B	$15.1 B
in each direction.				✓			N/A	N/A	N/A	N/A	0	453	0	598	$10.3B	$15.1 B
					✓		N/A	N/A	N/A	N/A	0	478	0	591	$10.3B	$15.1 B
Results in 12 to 14-lane	✓					✓	N/A	N/A	N/A	N/A	0	460	0	588	$10.8B	$15.8 B
cross-section		✓				✓	N/A	N/A	N/A	N/A	0	468	0	639	$10.8B	$15.8 B
			✓			✓	N/A	N/A	N/A	N/A	0	494	0	641	$10.8B	$15.8 B
				✓		✓	N/A	N/A	N/A	N/A	0	529	0	593	$10.8B	$15.8 B
					✓	✓	N/A	N/A	N/A	N/A	0	556	0	603	$10.8B	$15.8 B

Table 5-5 Transportation Analysis Results (Continued)

Separated Facilities															
	Operational Assumptions						Operational Results (Exclusive Car Lanes)		Operational Results (Exclusive Truck Lanes)		Operational Results (Non-Exclusive Truck Lanes)		Operational Results (General Purpose Lanes)			
	No Toll	Low Toll All	High Toll All	Low Toll Trucks	High Toll Trucks	With R3[5]	Deficient Miles[2]	Excess Miles[2]	Deficient Miles[2]	Excess Miles[2]	Deficient Miles[2]	Excess Miles[2]	Deficient Miles[2]	Excess Miles[2]	2005 Cost	2015 Cost
Separated Lane Concept 4[9]																
	✓						362	8	65	279	N/A	N/A	N/A	N/A	$11.2B	$16.4 B
Add two exclusive car lanes		✓					211	55	53	292	N/A	N/A	N/A	N/A	$11.2B	$16.4 B
in each direction plus zero			✓				168	76	40	426	N/A	N/A	N/A	N/A	$11.2B	$16.4 B
additional exclusive truck lanes				✓			362	8	42	369	N/A	N/A	N/A	N/A	$11.2B	$16.4 B
in each direction					✓		362	8	36	406	N/A	N/A	N/A	N/A	$11.2B	$16.4 B
	✓					✓	362	8	42	372	N/A	N/A	N/A	N/A	$11.7B	$17.1 B
Results in 8- to 10-lane		✓				✓	211	55	21	399	N/A	N/A	N/A	N/A	$11.7B	$17.1 B
cross-section			✓			✓	168	76	0	472	N/A	N/A	N/A	N/A	$11.7B	$17.1 B
				✓		✓	362	8	10	446	N/A	N/A	N/A	N/A	$11.7B	$17.1 B
					✓	✓	362	8	0	464	N/A	N/A	N/A	N/A	$11.7B	$17.1 B
Add two exclusive car lanes	✓						362	8	0	585	N/A	N/A	N/A	N/A	$12.2B	$17.9 B
In each direction plus one		✓					211	55	0	597	N/A	N/A	N/A	N/A	$12.2B	$17.9 B
exclusive truck lane in each			✓				168	76	0	610	N/A	N/A	N/A	N/A	$12.2B	$17.9 B
direction.				✓			362	8	0	608	N/A	N/A	N/A	N/A	$12.2B	$17.9 B
					✓		362	8	0	614	N/A	N/A	N/A	N/A	$12.2B	$17.9 B
Results in 10- to 12-lane	✓					✓	362	8	0	608	N/A	N/A	N/A	N/A	$12.7B	$18.6 B
cross-section		✓				✓	211	55	0	629	N/A	N/A	N/A	N/A	$12.7B	$18.6 B
			✓			✓	168	76	0	650	N/A	N/A	N/A	N/A	$12.7B	$18.6 B
				✓		✓	362	8	0	640	N/A	N/A	N/A	N/A	$12.7B	$18.6 B
					✓	✓	362	8	0	650	N/A	N/A	N/A	N/A	$12.7B	$18.6 B

Table 5-5 Transportation Analysis Results (Continued)

Separated Facilities																
	Operational Assumptions						Operational Results (Exclusive Car Lanes)		Operational Results (Exclusive Truck Lanes)		Operational Results (Non-Exclusive Truck Lanes)		Operational Results (General Purpose Lanes)			
	No Toll	Low Toll All	High Toll All	Low Toll Trucks	High Toll Trucks	With R3[5]	Deficient Miles[2]	Excess Miles[2]	Deficient Miles[2]	Excess Miles[2]	Deficient Miles[2]	Excess Miles[2]	Deficient Miles[2]	Excess Miles[2]	2005 Cost	2015 Cost
Separated Lane Concept 4[9]																
	✓						362	8	0	650	N/A	N/A	N/A	N/A	$12.5B	$18.3 B
		✓					211	55	0	650	N/A	N/A	N/A	N/A	$12.5B	$18.3 B
Add two exclusive car lanes in			✓				168	76	0	650	N/A	N/A	N/A	N/A	$12.5B	$18.3 B
Each direction plus two exclusive				✓			362	8	0	650	N/A	N/A	N/A	N/A	$12.5B	$18.3 B
trucks lanes in each direction.					✓		362	8	0	650	N/A	N/A	N/A	N/A	$12.5B	$18.3 B
	✓					✓	362	8	0	650	N/A	N/A	N/A	N/A	$13.0B	$19.0 B
Results in 12- to 14-lane		✓				✓	211	55	0	650	N/A	N/A	N/A	N/A	$13.0B	$19.0 B
cross-section			✓			✓	168	76	0	650	N/A	N/A	N/A	N/A	$13.0B	$19.0 B
				✓		✓	362	8	0	650	N/A	N/A	N/A	N/A	$13.0B	$19.0 B
					✓	✓	362	8	0	650	N/A	N/A	N/A	N/A	$13.0B	$19.0 B
Separated Lane Concept 5[10]																
	✓						141	36	N/A	N/A	N/A	N/A	171	105	$11.2B	$16.4 B
Add two exclusive car lanes in		✓					62	78	N/A	N/A	N/A	N/A	133	138	$11.2B	$16.4 B
each direction plus zero additional			✓				43	144	N/A	N/A	N/A	N/A	80	204	$11.2B	$16.4 B
general purposes lanes in each				✓			141	36	N/A	N/A	N/A	N/A	116	136	$11.2B	$16.4 B
direction					✓		141	36	N/A	N/A	N/A	N/A	104	185	$11.2B	$16.4 B
	✓					✓	141	36	N/A	N/A	N/A	N/A	104	158	$11.7B	$17.1 B
Results in 8- to 10-lane		✓				✓	62	78	N/A	N/A	N/A	N/A	96	188	$11.7B	$17.1 B
cross-section			✓			✓	43	144	N/A	N/A	N/A	N/A	51	274	$11.7B	$17.1 B
				✓		✓	141	36	N/A	N/A	N/A	N/A	65	187	$11.7B	$17.1 B
					✓	✓	141	36	N/A	N/A	N/A	N/A	63	242	$11.7B	$17.1 B

Table 5-5 Transportation Analysis Results (Continued)

Separated Facilities																
	Operational Assumptions						Operational Results (Exclusive Car Lanes)		Operational Results (Exclusive Truck Lanes)		Operational Results (Non-Exclusive Truck Lanes)		Operational Results (General Purpose Lanes)			
	No Toll	Low Toll All	High Toll All	Low Toll Trucks	High Toll Trucks	With R3[5]	Deficient Miles[2]	Excess Miles[2]	Deficient Miles[2]	Excess Miles[2]	Deficient Miles[2]	Excess Miles[2]	Deficient Miles[2]	Excess Miles[2]	2005 Cost	2015 Cost
Separated Lane Concept 5[10]																
Add two exclusive car lanes in Each direction plus one general purpose lane in each direction. Results in 10- to 12-lane cross-section	✓						141	36	N/A	N/A	N/A	N/A	0	479	$12.2B	$17.9 B
		✓					62	78	N/A	N/A	N/A	N/A	0	517	$12.2B	$17.9 B
			✓				43	144	N/A	N/A	N/A	N/A	0	570	$12.2B	$17.9 B
				✓			141	36	N/A	N/A	N/A	N/A	0	534	$12.2B	$17.9 B
					✓		141	36	N/A	N/A	N/A	N/A	0	546	$12.2B	$17.9 B
	✓					✓	141	36	N/A	N/A	N/A	N/A	0	546	$12.7B	$18.6 B
		✓				✓	62	78	N/A	N/A	N/A	N/A	0	554	$12.7B	$18.6 B
			✓			✓	43	144	N/A	N/A	N/A	N/A	0	599	$12.7B	$18.6 B
				✓		✓	141	36	N/A	N/A	N/A	N/A	0	585	$12.7B	$18.6 B
					✓	✓	141	36	N/A	N/A	N/A	N/A	0	587	$12.7B	$18.6 B
Add two exclusive car lanes in each direction plus two general purpose lanes in each direction. Results in 12- to 14-lane cross-section	✓						141	36	N/A	N/A	N/A	N/A	0	650	$12.5B	$18.3 B
		✓					62	78	N/A	N/A	N/A	N/A	0	650	$12.5B	$18.3 B
			✓				43	144	N/A	N/A	N/A	N/A	0	650	$12.5B	$18.3 B
				✓			141	36	N/A	N/A	N/A	N/A	0	650	$12.5B	$18.3 B
					✓		141	36	N/A	N/A	N/A	N/A	0	650	$12.5B	$18.3 B
	✓					✓	141	36	N/A	N/A	N/A	N/A	0	650	$13.0B	$19.0 B
		✓				✓	62	78	N/A	N/A	N/A	N/A	0	650	$13.0B	$19.0 B
			✓			✓	43	144	N/A	N/A	N/A	N/A	0	650	$13.0B	$19.0 B
				✓		✓	141	36	N/A	N/A	N/A	N/A	0	650	$13.0B	$19.0 B
					✓	✓	141	36	N/A	N/A	N/A	N/A	0	650	$13.0B	$19.0 B

Table 5-5 Transportation Analysis Results (Continued)

Table Notes:

Note: Operational Results represent325 miles in each direction or 650 total miles.

1 TSM = Transportation System Management projects. TSM includes safety, climbing lanes, ITS, Park & Ride lot projects TSM Enhancements included in all concepts carried forward.
2 Rail 1 includes minor level improvements to the Norfolk Southern Piedmont Line from Manassas to Front Royal, VA and north to the state line.
3 Rail 2 includes full level of improvements to the Norfolk Southern Piedmont Line within the Commonwealth of Virginia, including Rail 1.
4 New Rail Freight hauling technology with Intermodal centers at major intersections.
5 Rail 3 includes expansion of Rail 2 to include minor improvements to the Norfolk Southern Shenandoah line within Commonwealth of Virginia, and as the rail alternative tested against the highway operational assumptions because Rail 3 provides the best cost-benefit reduction along I-81.
6 Based on AASHTO Standards for Levels of Service: Rural-LOS B & Urban-LOS C
7 Exclusive truckway provides separate access/egress at all interchanges from a separated lane or separated lanes. Only trucks can travel in the separated lanes. Cars must travel in exclusive car lanes and use existing interchange configuration.
8 Non-Exclusive truckway allows trucks in separated lanes to cross into general purpose lanes to access existing interchanges. Only trucks can travel in the separated lanes. Cars can only travel in general purpose lanes. However, trucks can also use the general purpose lanes to access/egress existing interchanges. Up to 70 percent of trucks are expected to use the general purpose lanes. It is assumed that trucks do not travel in these lanes for long distances.
9 Exclusive car lanes provide separate access/egress at all interchanges from separated lanes. Only cars can travel in the separated lanes. Trucks must travel in exclusive truck lanes and use existing interchange configuration.
10 Exclusive car lanes provide separate access/egress at all interchanges from separated lanes. Only cars can travel in the separated lanes. Trucks must travel in the general purpose lanes. However, cars can choose to travel in either the exclusive or general purpose lanes for their entire trip. Twenty percent of cars are expected to use the general purpose lanes

Highway Widening Concepts

The results show that the add one lane in each direction and uniform six-lane cross-section concepts do not sufficiently increase capacity to address the purpose and need. Similarly, the add two lanes in each direction, uniform eight-lane, and add three lanes in each direction concepts involve the construction of a sizeable amount of excess capacity.

Separated Facilities

Several conclusions can be drawn from the evaluation of separated truck and car facilities.

Separated Lane Concept 1

This concept does not adequately increase capacity for trucks and provides a sizeable amount of excess capacity for passenger cars. More importantly, this concept provides only one travel lane in each direction for trucks. Providing only one lane per direction has the ability to create multiple safety hazards for all users of I-81. These safety hazards include a lack of freedom for trucks to maneuver around disabled trucks, the potential of a complete breakdown in operations in the event of an incident, and a potential hindrance of response time in the event of an emergency. Furthermore, should the separated facility need to be closed for a period of time, the adjacent facility would not have sufficient capacity to handle traffic volume.

Separated Lane Concept 3

As explained in the *Concept Development Technical Report*, this concept provides a rumble strip separation between the truck lanes and the car lanes. Trucks would have to maneuver over this rumble strip to enter and exit I-81 at the existing interchanges. Regardless of the operational results (which show there may be sections of the corridor where a separated facility is appropriate), the construction of a non-exclusive facility would create multiple uncontrolled weaving and multi-merge segments throughout the corridor. These uncontrolled weave and merge maneuvers could substantially decrease safety along the I-81 within Virginia.

Separated Lane Concepts 2, 4, and 5

The evaluation results show that these concepts provide a sizable amount of excess capacity over the entire 325-mile length of I-81 in Virginia. However, the results indicate that a separated facility may be appropriate for a portion of the corridor. Furthermore, construction of an exclusive separated facility, with separate access and egress locations to and from I-81, would address safety concerns along the corridor.

5.4 Results of Secondary Impacts Analysis on U.S. Route 11

As mentioned previously, the Tier 1 analysis criteria investigated secondary transportation impacts to U.S. Route 11 due to improvements on I-81. These impacts are summarized in the following sections.

5.4.1 Future Effects of Potential I-81 Improvements to U.S. Route 11

U.S. Route 11 is one of the main parallel travel routes to I-81, and the road most directly impacted by traffic congestion on I-81. It was therefore important to evaluate how traffic would change on U.S. Route 11 under three different basic conditions: 1) future growth by 2035 without any improvements on I-81 (No-Build), 2) traffic volume changes on U.S. Route 11 as a result of increased capacity on I-81, and 3) potential diversions onto U.S. Route 11 as a result of the implementation of a toll on I-81.

2035 No-Build daily traffic volumes were prepared for U.S. 11 using a travel demand model assignment procedure, as described in detail in the *Tolling Impact Study*. Traffic volume changes due to improvements to I-81 were estimated based on both traffic shifts off existing roads as well as induced demand. Toll diversions were then estimated for two tolling scenarios (referred to as high and low).

Traffic operations on U.S. Route 11 were evaluated by developing daily traffic capacities at the Level of Service D/E threshold. As defined in the *Highway Capacity Manual*, a roadway reaches capacity when its volume to capacity (v/c) ratio equals 1.0, at LOS E. Daily volumes were then divided into daily capacities to produce roadway v/c ratios. In rural areas, v/c ratios below 0.56 generally indicate that a roadway are operating at or better than LOS B. In urban areas, v/c ratios below 0.74 generally indicate that a roadway is operating at or better than LOS C. Table 5-6 presents a summary of future year 2035 traffic operations on U.S. Route 11.

Table 5-6 2035 Future Traffic Operations on U.S. Route 11

	Volume to Capacity Ratio[2]			
Location[1]	2035 No Build	2035 "Build" No Toll	2035 "Build" Low Toll	2035 "Build" High Toll
TN State Line	0.80	0.80	0.80	0.80
Washington/Smyth	0.40	0.39	0.69	0.80
Smyth/Wythe	0.17	0.17	0.61	0.87
South of Exit #72	0.15	0.06	0.28	0.45
Between Exit #72 and #81	*1.04*	*0.58*	*0.54*	*0.50*
North of Exit #81	*0.99*	*0.57*	*0.53*	*0.47*
Pulaski/Montgomery	0.50	0.44	0.48	0.55
Montgomery/Roanoke	0.65	0.48	0.51	0.64
South of Exit #137	0.77	0.68	0.68	0.70
North of Exit #146	0.81	0.53	0.64	0.68
Roanoke/Botetourt	0.81	0.53	0.64	0.68
South of Exit #191	0.53	0.48	0.50	0.63
Rockbridge/Augusta	0.83	0.03	0.11	0.58
North of Exit #221	0.30	0.11	0.34	0.32
Augusta/Rockingham	0.87	0.54	0.82	0.85
South of Exit #247	1.34	1.20	1.28	1.28
North of Exit #251	1.03	0.68	0.88	0.99
Rockingham/Shenandoah	1.01	0.67	0.96	1.10
Shenandoah/Frederick	0.86	0.45	0.65	0.85
South of Exit #310	1.02	0.85	1.04	1.10
South of Exit #317	1.54	1.48	1.57	1.65
WV State Line	0.76	0.76	0.76	0.76

1. Locations in italics indicate roadway sections where U.S. Route 11 is signed concurrently with I-81.
2. Volume to Capacity Ratio is based on the Level of Service D/E threshold equaling a V/C ratio of 1.0.

Impacts of Roadway Widening on I-81

With the implementation of capacity improvements on I-81, substantial traffic volume shifts and induced traffic result in daily traffic volume changes on U.S. Route 11. Overall, the impact of I-81 improvements in almost all cases is a reduction in traffic on U.S. Route 11. In a few locations, this diversion may be substantial enough to reduce 2035 traffic volumes close to existing traffic volumes. However, in most locations, the traffic reduction is more moderate in scale. With I-81 widening, congested conditions still occur in the Harrisonburg and Winchester areas, but to a lesser extent.

Impacts of Potential Tolls on I-81

As identified previously and detailed in the *Tolling Impact Study*, with the high toll scenario, the greatest impacts (higher volume) are projected on U.S. Route 11 between Bristol and the Smyth/Wythe County line. Areas with moderate increases include between the Smyth/Wythe County line and Wytheville, between the Botetourt/Rockbridge County line and Lexington, between Maury (Exit 257) and Woodstock (Exit 283), and between Middletown (Exit 302) and Kernstown (Exit 310).

With the low toll scenario, moderate volumes increases occur on U.S. Route 11 only at two segments near the two ends of the study area, the first between Bristol and the Smyth/Wythe County line, and the second between Middletown (Exit 302) and Kernstown (Exit 310).

5.5 Safety Effects

Crash statistics for a recent three-year period along I-81 revealed 5,746 reported crashes along the corridor. Seventy-one (one percent) of these crashes involved fatalities and 2,098 crashes (36.5 percent) involved personal injury to 3,095 persons.

For the goal of increasing highway safety, there are three general objectives: reduce highway fatalities; reduce overall highway crashes; and, improve heavy vehicle safety on the highway. Much of the safety assessment of I-81 concepts is qualitative rather than quantitative in nature due to the lack of reliable predictive tools to estimate the safety effects of the individual concepts under consideration.

Safety benefits from the I-81 improvement program are expected to come from three primary areas: geometric improvements; operational improvements, and management strategies (reduced exposure), as described below.

Geometric Improvements

Major crash types observed from the historic data indicate that 41 percent of crashes involved collisions with a fixed object. These generally involve run-off-road (ROR) type collisions. *Every* concept, except the No-Build condition, is expected to reduce the potential for this condition by:

- Eliminating the more than two-thirds of the corridor that has inadequate inside shoulder widths based on the volume, particularly heavy vehicles, using the corridor;
- Providing rumble strips along the shoulders throughout the corridor[28]; and,
- Improving deficient interchange geometry.

28 Prior VDOT analysis of this action alone showed a potential decrease in ROR collisions of about 50 percent.

Additional analysis found that 19 percent of crashes involved rear-end type collisions and 18 percent were sideswipe crashes between two vehicles traveling in the same direction. *Every* concept, except the No-Build condition, is expected to reduce the potential for this condition by:

- Addressing the congested conditions along the corridor that cause speed differentials among motorists that contribute to these types of crashes by adding additional through capacity[29] and truck climbing (and/or truck separated) lanes;
- Mitigating the existing interchanges (about 70 percent of the total) that have geometric deficiencies; and,
- Improving the more than 100 locations of insufficient sight distances that exist due to the vertical alignment of the highway;

Operational Improvements

I-81 concepts may also improve corridor safety conditions by reducing overall exposure to risk. The potential for crashes vary widely by facility type (e.g. interstate vs. arterial roadway) and exposure (generally, the more vehicles or vehicle miles traveled (VMT) on a facility, the more crashes are expected to occur). Therefore, concepts that shift VMT amongst facility types or concepts that reduce overall VMT (such as concepts that shift freight movement from truck to rail) have the potential to affect crash rates (either positively or negatively).

The general risk for traffic crashes has been long demonstrated to vary by highway functional class. Table 5-7 presents motor vehicle fatality rates by highway functional system calculated by the Bureau of Transportation Statistics.

29 Historic research has shown that six-lane (or more) freeways have lower crash rates than four-lane freeways and that the rate of increase in crashes as traffic grows is higher for four-lane highways than for six-lane and eight-lane highways; however, little recent research has verified these trends.

Table 5-7 Nationwide Motor Vehicle Fatality Rates by Highway Functional System for 1998

Highway Functional System	Fatality Rate (per 100 million vehicle miles)
Rural	2.39
Interstate	1.23
Other Arterial	2.38
Collector	2.94
Local	3.70
Urban	1.01
Interstate	0.61
Other Arterial	1.15
Collector	0.79

U.S. highway fatal crash rates by functional highway system indicate that the rates on interstate highways are almost half comparable rates on other arterial roadways. Therefore, concepts that decrease VMT on the lower functional classes such as local roads and, instead, divert those vehicle miles to higher functional class highways such as I-81 are expected to increase the overall highway safety through the corridor. The top two performing concepts in this regard are "Build" No Toll and "Build" No Toll plus Rail 3 improvements due to their potential to divert traffic from corridor arterial roadways, like Route 11, to an improved I-81 corridor. These are followed closely by the Low Toll and Low Truck Toll variation on these concepts. Build concepts that feature high tolls along I-81 are not as effective in moving vehicles from lower classes of roadways to I-81 because of cost of I-81 travel is not sufficiently offset by travel time benefits to persuade motorists to change routes.

Concepts that reduce overall VMT, such as concepts that shift freight movement from truck to rail, also have the potential to affect positively affect crash rates. Only Concepts that include Rail 3 improvements have the potential to reduce the risk of crashes along I-81, specifically for heavy vehicles, by reducing exposure through the corridor.

Management Strategies

It is currently envisioned that trucks would be prohibited from traveling in the left-most lane if the I-81 corridor is improved to six or more lanes. There have been no conclusive studies documenting the safety benefits of left-lane truck restrictions[30]; however, a number of independent studies have concluded a safety benefit would accrue from such a restriction:

30 A list of the research studies reviewed as part of this project are included in the appendix to this Technical Report.

- One study in Houston showed short-term crash reduction on an urban six-lane freeway after the implementation of the restriction.
- Left-lane truck restrictions tend to reduce lane changes in general on all terrain which is a contributing factor in the occurrence of crashes.
- Trucks tend to cluster more in the outside two lanes, which could create sign visibility issues and may make ramp entering and exiting more difficult. This clustering effect may create safety issues in the vicinity of interchange off-ramps and on-ramps.
- In general, left-lane truck restrictions are deemed to have the greatest benefit in areas where grades are 4 percent or higher and have high truck volumes.
- In flat terrain, speed benefits appear to be negligible. No safety studies were found to draw conclusion on the safety of left-lane truck restrictions. In areas with variable (but not steep) terrain, speed benefits seemed to increase for passenger cars.
- There was limited information on the operational effects of left-lane truck restrictions on overall density and level of service on a freeway. Several studies in urban areas concluded that traffic operations (level of service) were unaffected by the introduction of a left-lane truck restriction.
- In urban areas, slower-moving passenger cars and tractor-trailers tend to gravitate to the middle lane, to avoid both the interchange ramp traffic and high-speed traffic in the left lane. In rural areas with widely-spaced interchanges, tractor-trailers more often tend to stay in the right lane, while slow-moving passenger cars tend to stay in the middle lane. This can cause a conflict on a freeway with a left-lane truck restriction on level terrain, as the middle lane is the "passing lane" for trucks and the slow lane for passenger cars.

5.6 Summary of Results

The Tier 1 concepts were subjected to tolls scenarios and rail improvements to illustrate an associated range of impacts. Should a "Build" concept (or portion of a "Build" concept) be advanced to Tier 2, these impacts would be quantified in specific detail. Quantification of these impacts would lead to further refinement and elimination of some concepts as part of the Tier 2 process.

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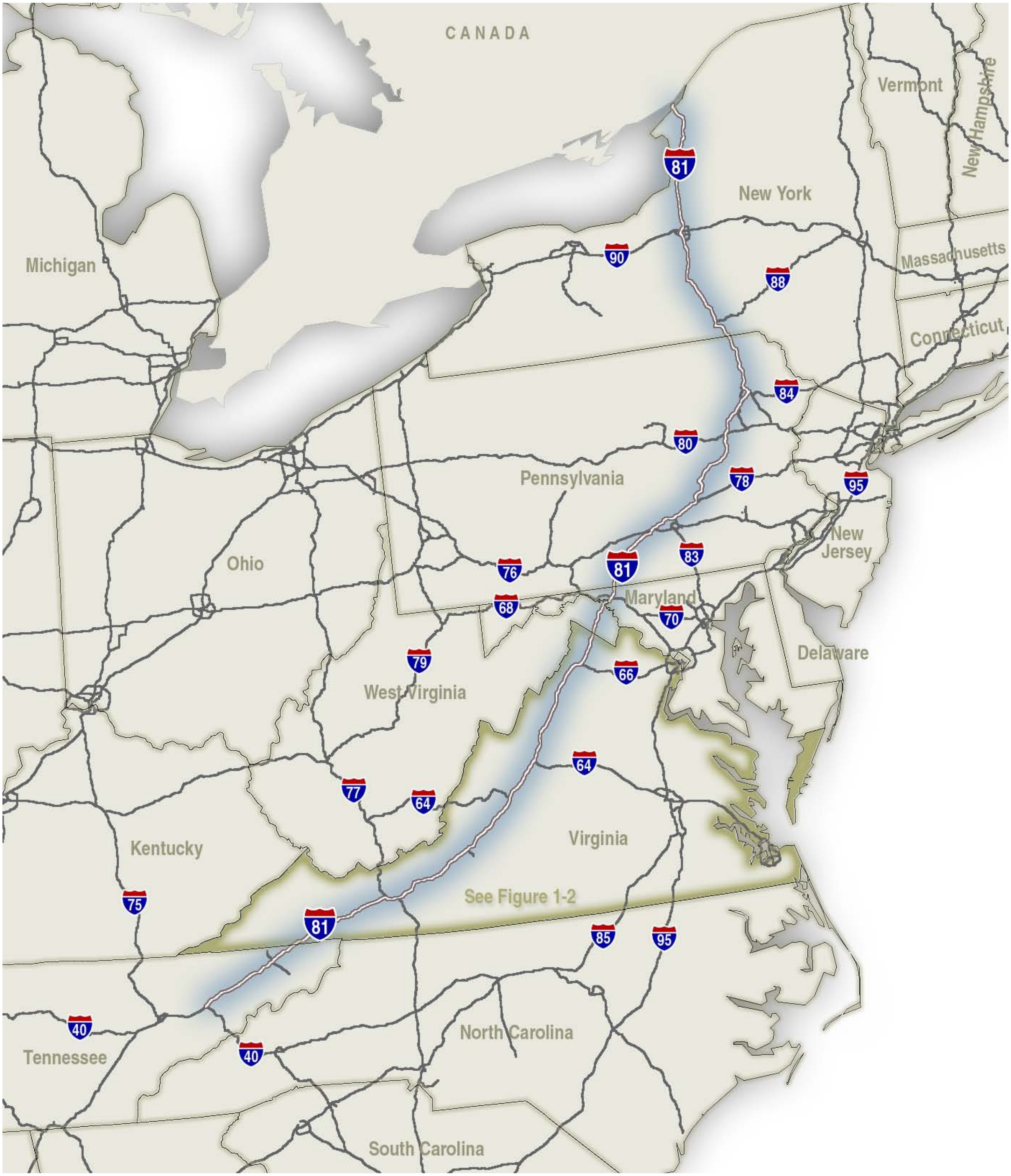

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North

I-81 Corridor Study

Transportation Technical Report

I-81 within the Eastern United States Interstate System

Figure 1-1

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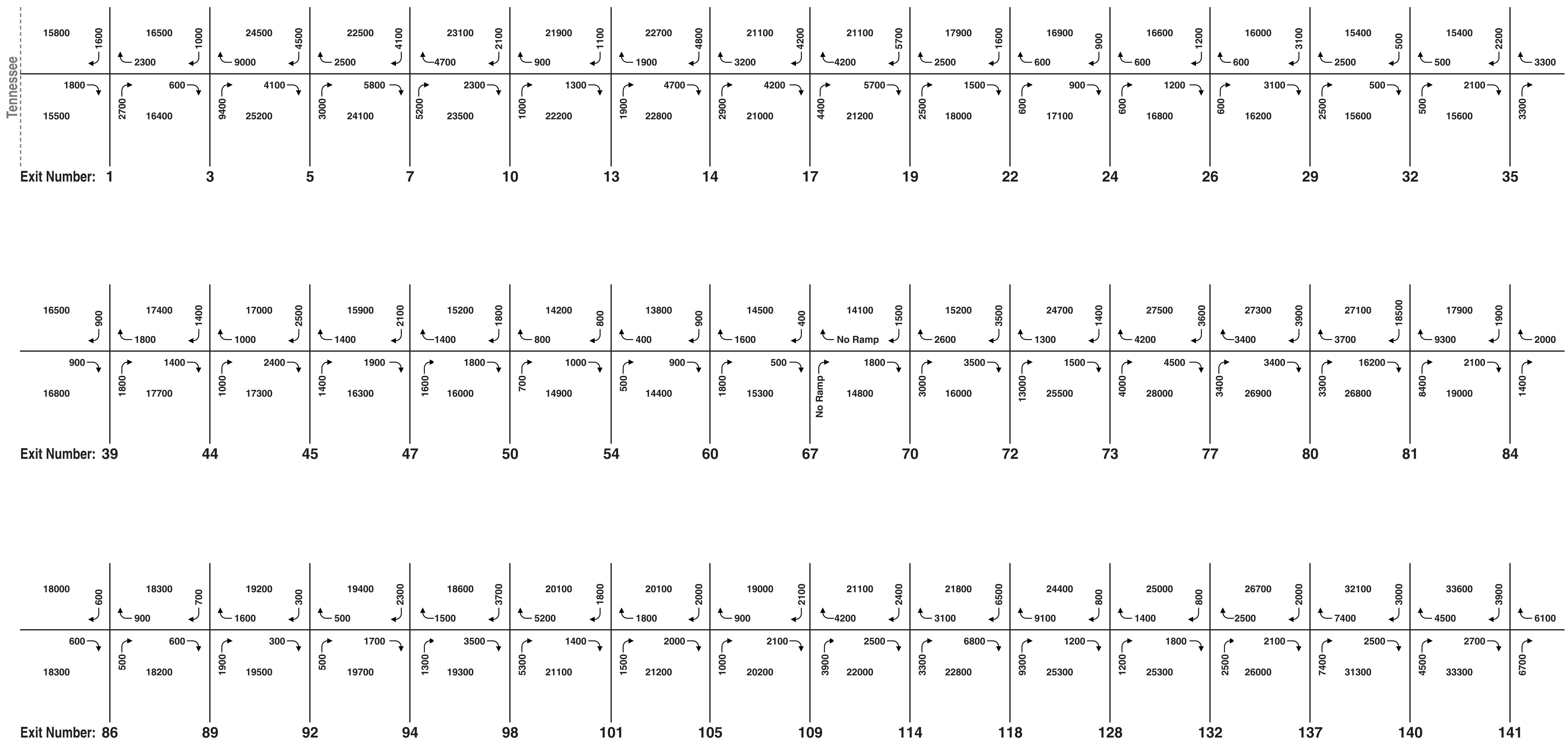
I-81 within Virginia

Figure 1-2

I-81 CORRIDOR IMPROVEMENT STUDY



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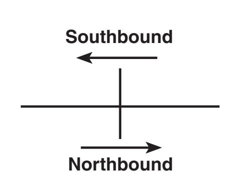
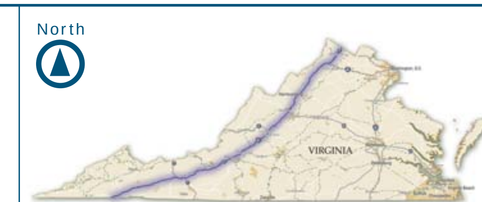
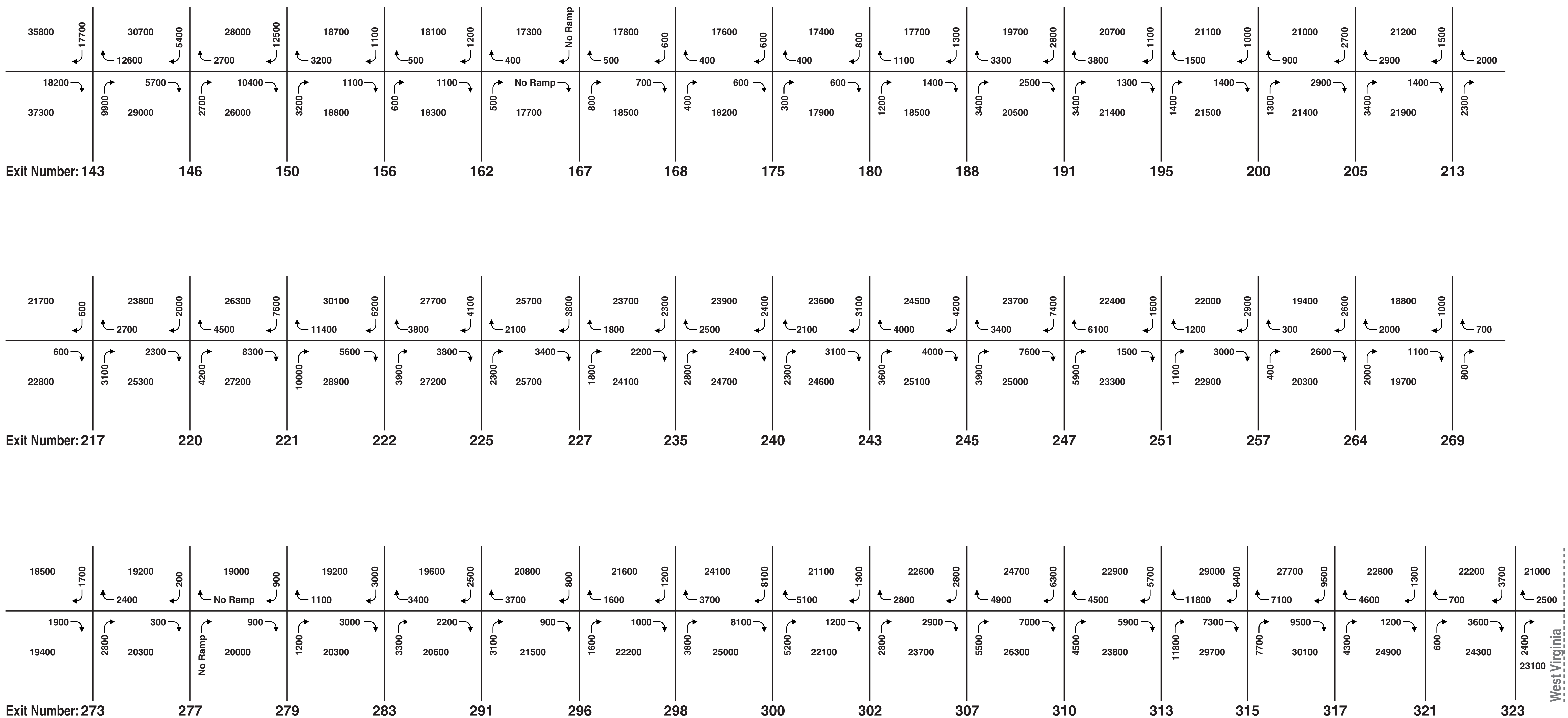




2004 Existing Daily Traffic Volumes

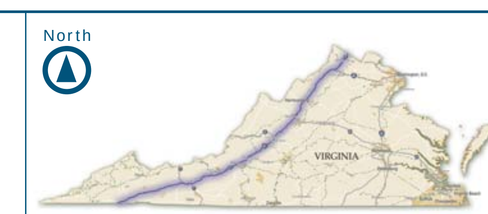
Figure 3-1

I-81 CORRIDOR IMPROVEMENT STUDY



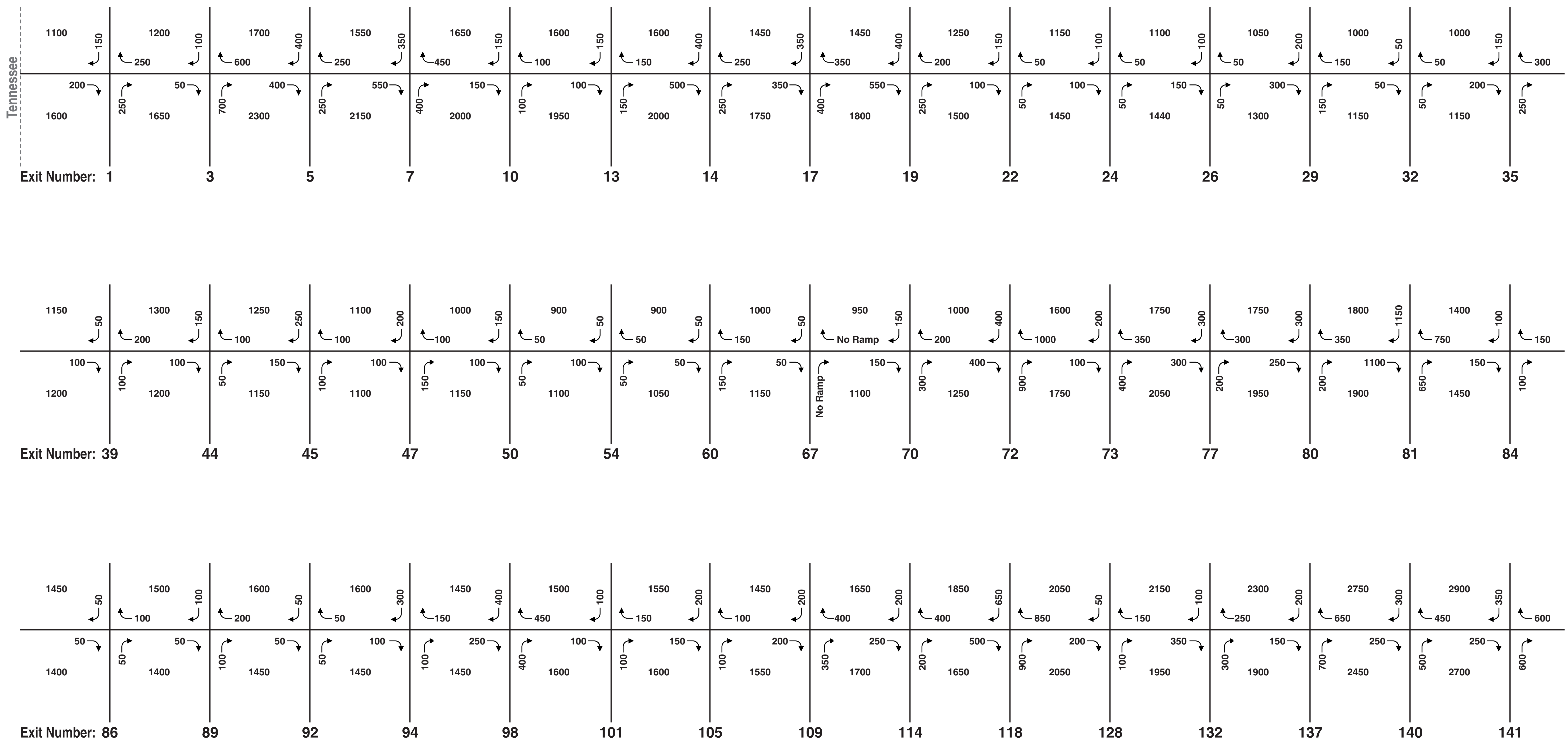
Southbound

Northbound



2004 Existing Daily Traffic Volumes

Figure 3-1 (Cont.)



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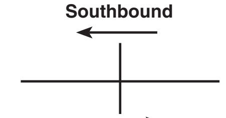
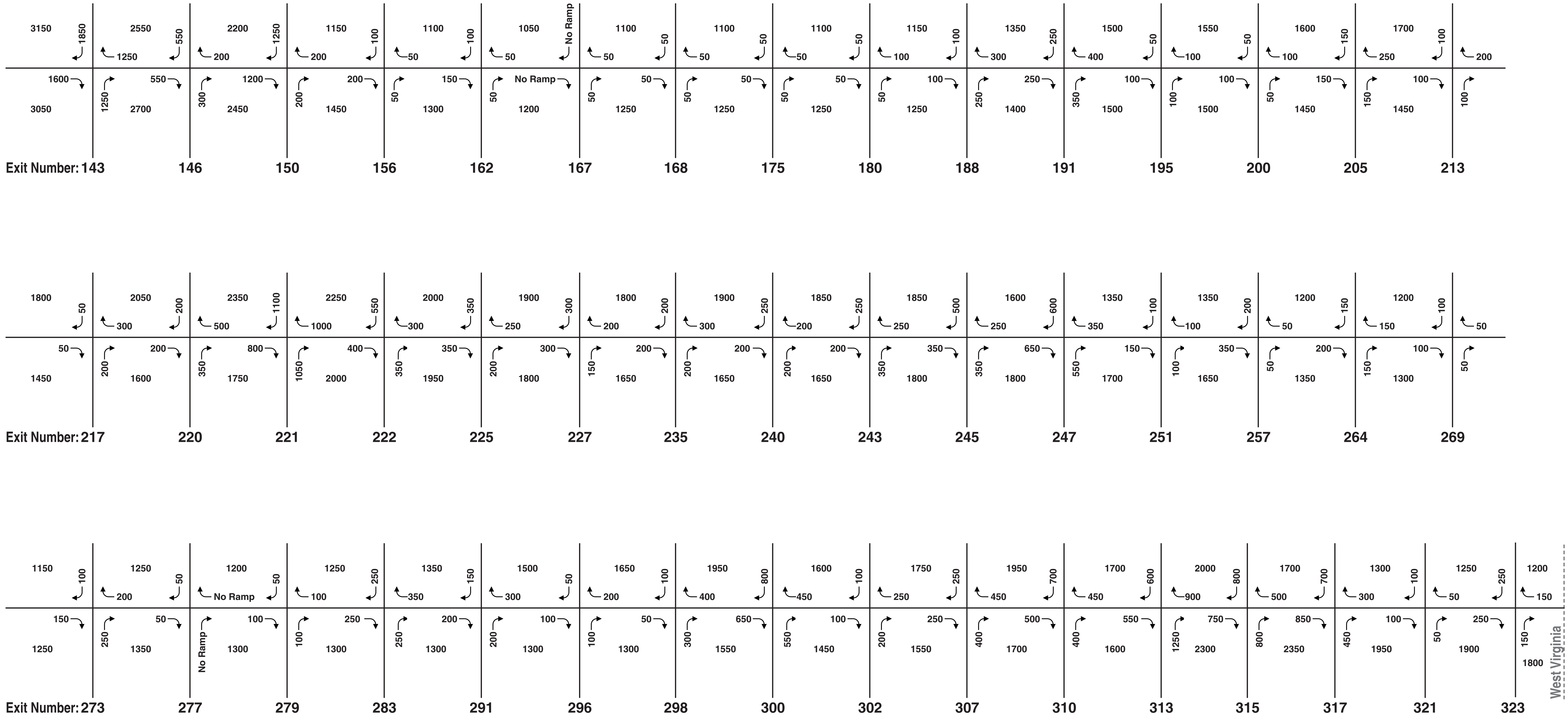


2004 Existing Peak Hour Traffic Volumes

Figure 3-2



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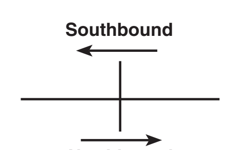
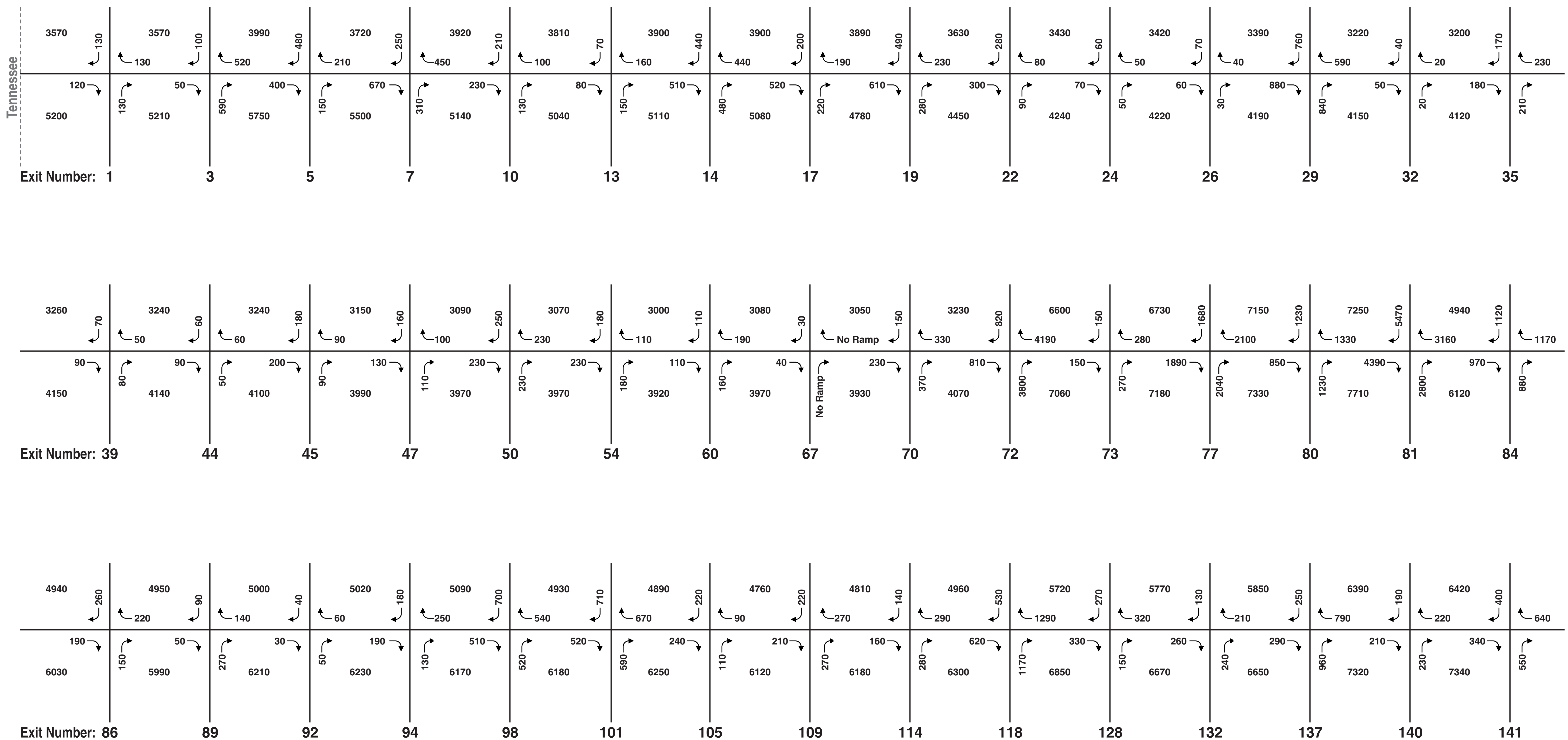


2004 Existing Peak Hour Traffic Volumes

Figure 3-2 (Cont.)



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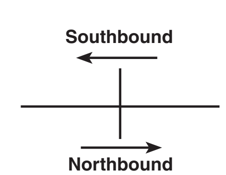
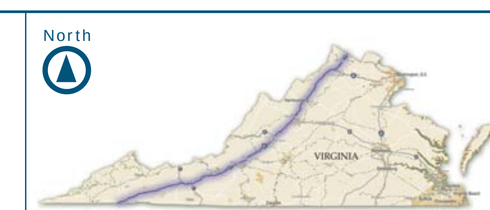
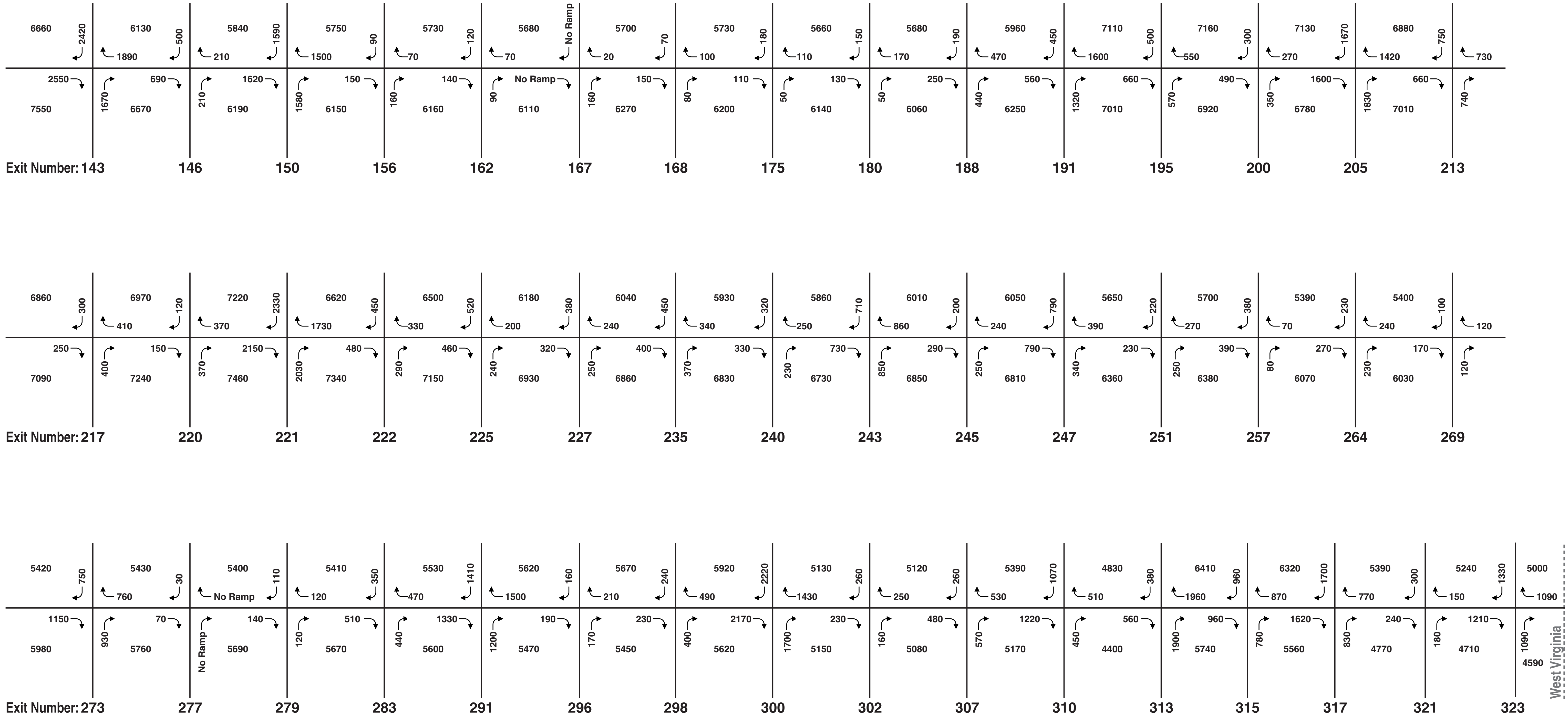


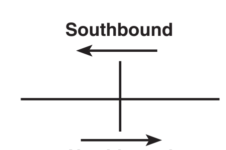


2004 Existing Daily Heavy Vehicle Volumes

Figure
3-3

I-81 CORRIDOR IMPROVEMENT STUDY





2004 Existing Daily Heavy Vehicle Volumes

Figure 3-3 (Cont.)